ME 1755

OPERATING AND SERVICING MANUAL FOR THERMAL TRANSFER VOLTMETER MODEL 6A

Holt Instrument Laboratories

OCONTO • WISCONSIN • 54153 • PHONE: 414 834-2222

DESIGNERS & MANUFACTURERS OF ELECTRONIC INSTRUMENTATION

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_07719

OPERATING AND SERVICING MANUAL FOR THERMAL TRANSFER VOLTMETER MODEL 6A

THIS MANUAL TO ACCOMPANY

INSTRUMENT NO. ----------

December 1968

HOLT INSTRUMENT LABORATORIES

OCONTO, WISCONSIN

TABLE OF CONTENTS

Paragraph No.		Page No.
	SECTION 1 - INTRODUCTION	
1.1	General Description	1-1
	Technical Specifications	1-2
	SECTION 2 - OPERATING INSTRUCTIONS	
2.1	Preparation for Use	2-1
2.2	Operating Controls	2-1
2.3	Applications	2-3
	SECTION 3 - THEORY OF OPERATION	
3.1	General Theory	3-1
3.2	Basic Circuit Theory	3-1
3.3	Input Circuit	3-2
3.4	Protective Circuits	3-4
3.5	Balance Circuit	3-4
3.6	Null Indicating Circuit	3-5
3.7	Null Detector	3-6
3.8	Power Supply	3-6
	SECTION 4 - RECALIBRATION	
4.1	Recommended Test Equipment	4-1
4.2	Null Detector	4-1
4.3	Periodic Maintenance	4-1
4.4	Calibration Subsequent to Repair	4-1
4.5	Frequency Response	4-2
	SECTION 5 - SERVICING	
5.1	Voltage Measurements	5-1
5.2	Conditions for Voltage Measurements	5-1
5.3	DC Voltage Measurements	5-1
5.4	AC Voltage Measurements	5-1
5.5	Component Locations	5-1
	SECTION 6 - LIST OF REPLACEABLE PARTS	
6.1	Parts Description	6-1
6.2	Parts Illustrations	6-1

LIST OF ILLUSTRATIONS

Figure No.	Title	Page No.
1	Thermal Transfer Voltmeter - Model 6A	1-1
2	Operating Controls and Terminals	2-4
3	Typical Test Set-up for Model 6A Thermal Transfer Voltmeter	2-5
4	Block Diagram of the Model 6A	3-1
5	Input Circuit for Voltage Measurements	3-2
6	Input Circuit for Current Measurements	3-3
7	Protective Circuits	3-3
8	Null Detector Block Diagram	3-5
9	Location of Trimmer Capacitors	4-2
10	Model 6A Interior - Bottom View	5-2
11	Model 6A Interior - Top View	5-2
12	Model 6A Interior - Side View	5-3
13	Cutout Circuit Assembly	5-3
14	Thermocouple Circuit Assembly	5-3
15	Range Switch Assembly - Front View	5-4
16	Range Switch Assembly - Rear View	5-4
17	Null Detector Power Supply Board (Detail 1)	5-5
18	Null Detector Power Supply Board (Detail 2)	5-5
19	Null Detector Amplifier Board (Detail 1)	5-6
20	Null Detector Amplifier Board (Detail 2)	5-6

The unit schematics appear at the end of the text.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or it is damaged in any way, a claim should be filed with the carrier. Also, notify Holt Instrument Laboratories or the local representative immediately. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electron tubes, fuses, and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid, and when upon our examination it is to our satisfaction defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.

2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins if such work is not covered by warranty. All shipments of Holt Instrument Laboratories' equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

1-31-69

ADDENDUM

HOLT MODELS 6 AND 6A

Items R27, R28 and R29 on LIST OF REPLACEABLE PARTS to read as follows:

Circuit Symbol	Description	Holt Part No.	Mfg.	Catalog Number
R27	Resistor, Wire Wound 200 K ohms, 10 Watts, ± 5%	85110	Holt	
R28	Resistor, Wire Wound 100 K ohms, 10 Watt, ± 5%	85109	Holt	
R29	Resistor, Wire Wound 60 K ohms, 2 Watts, ± 5%	85108	Holt	

SECTION 1
INTRODUCTION

1.1 General Description

a. The Holt Thermal Transfer Voltmeter - Model 6A is an AC-DC transfer standard with broad voltage and frequency range. The Model 6A provides NBS traceable precision AC voltage measurement in a compact package usable where space is at a premium. The Model 6A contains a solid state null detector capable of high resolution under all ambient light conditions and in all physical positions. The primary function of the Model 6A is to compare the thermal effect of an unknown RMS value of AC current or voltage with the thermal effect of a DC voltage whose magnitude is known or can be accurately measured.

b. The Model 6A is equipped with fourteen voltage ranges permitting its use on virtually every full scale meter range. Since each range on the Model 6A is usable from 50% to 100%, any input voltage from 0.25 to 1000 volts is measurable. Extremely low reversal error (less than ± 0.01%) eliminates the necessity to reverse the DC input or to calculate correction factors.

c. The Model 6A has been designed to operate over a broad frequency range. This allows its use as a standard in determining the influence of frequency on less sensitive devices. The usable range of the Model 6A is from a minimum frequency of 5 Hertz up to 1 megahertz (at 10 volts maximum). The use of Holt Model 20 High Frequency Thermal Converters, in the front panel receptacle provided, will extend the usable high frequency to 30 megahertz.

d. The Model 6A is equipped with a fully protected thermoelement. This protective circuitry virtually eliminates expensive thermoelement burnout and time consuming replacements. The protective circuit is capable of protecting the thermoelement against overloads up to 2000 times rated range. This feature permits the use of the instrument outside of the standards lab by relatively unskilled personnel.

e. Although the Model 6A was designed as a transfer standard for AC voltage measurements, a front panel receptacle and range switch position allow direct use of the Holt Model HCS-1 AC Current Shunt Set for the measurement of AC current ranges up to 20 amperes.

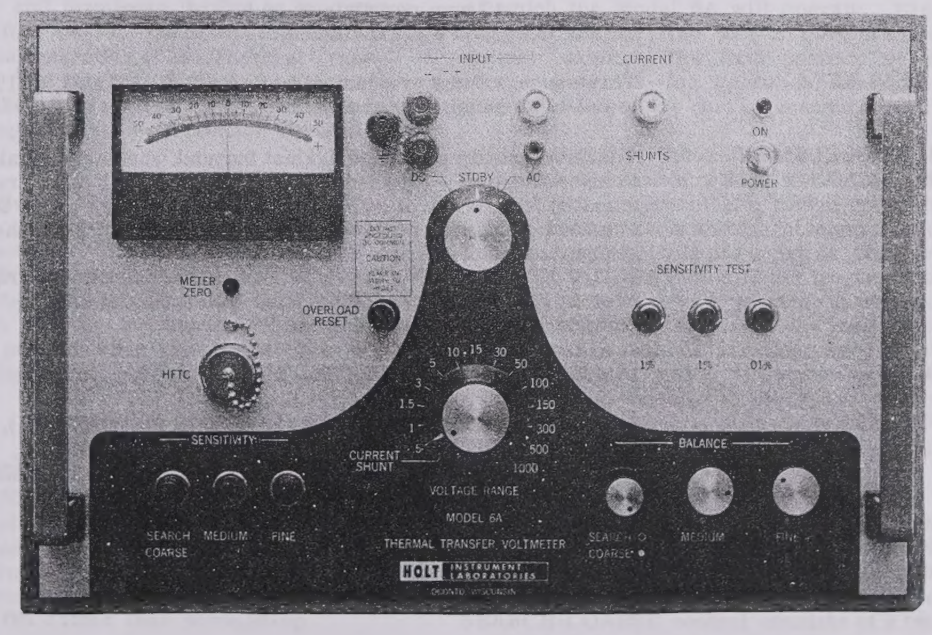


Figure 1. Thermal Transfer Voltmeter - Model 6A

TECHNICAL SPECIFICATIONS

THERMAL TRANSFER VOLTMETER

MODEL 6A

VOLTAGE RANGES:

0.5, 1, 1.5, 3, 5, 10, 15, 30, 50, 100, 150, 300, 500 and 1000 volts RMS.
NOTE: Each range used from 50% to 100% of range setting. Maximum applied voltage should not exceed 1000 V RMS.

ACCURACY: (Max. AC-DC Difference*)

	5 Hz thru 20 kHz	thru 50 kHz	thru 100 kHz	thru 500 kHz	thru 1 MHz
0.5 thru 10 volt range	± .005%	± .01%	± .05%	± .10%	± .10%
15 thru 50 volt range	± .005%	± .01%	± .05%	± .10%	------
100 thru 500 volt range	± .01%	± .01%	± .20%	------	------
1000 volt range	± .02%	± .04%	± .50%	------	------

*NOTE: Stated as deviations from zero AC-DC difference (in percent of applied voltage) as defined by and traceable to the National Bureau of Standards.

THERMOELEMENT REVERSAL ERROR:

Less than ± 0.01% at any applied voltage 50% to 100% of range.

INPUT RESISTANCE:

185 ohms/volt nominal.

NULL DETECTOR:

Internal, electronic, all solid-state circuitry.
Meter: 3-1/2" zero center scale with 50 scale divisions either side of zero.
Resolution: 10 ppm per division at 100% of range.
40 ppm per division at 50% of range.
Noise: Less than ± 1.5 divisions.

SENSITIVITY TEST KEYS:

Three push buttons provide calibrated offsets, at null, of 1%, 0.1% or 0.01% to establish sensitivity at any level.

COMPLETE THERMOELEMENT PROTECTION:

Thermoelements protected against burnout when accidentally subjected to any voltage, 0 - 1250 volts DC or AC RMS (to 1 MHz), regardless of duration or polarity of overload or control settings at the time of the overload. Holt will replace any accidentally burned-out thermo-elements free of charge.

MECHANICAL:

10-1/2" H x 15-7/8" W x 6-1/2" D Bench Mount (Model 6A).
10-1/2" H x 19" W x 4-1/2" D Rack Mount (Model 6AR).
Weight: 20 pounds approximate.

INPUT POWER:

105-125 VAC, 50, 60 or 400 Hz, 2 Watts.

SEMI-CONDUCTORS:

2N508A (2), 2N1306 (4), 2N1307 (3), 2N2322 (2), 2N3053 (1), 2N3638 (1), 2N3643 (1), 2N5133 (8), 1N440B (8), 1N618 (2), 1N628 (4), 1N753A (1), 1N2765 (1), 1N3640 (2), 4D4 (2), NS2004 (2).

FUSES:

1/8 amp.

SECTION 2

OPERATING INSTRUCTIONS

2.1 Preparation for Use

a. General. The Thermal Transfer Voltmeter is supplied, factory tested and calibrated in a single shipping container. The customer need only make the power connections as indicated below. The Model 6A should require no preliminary service by the customer.

b. Power Connections. The power cord is terminated in a three prong, polarized male connector. Connect the large rectangular pin to the common side of the AC power line and the small rectangular pin to the hot side of the line. The large round pin of the connector is wired directly to the chassis of the instrument. It is important that this pin be connected directly to a good earth ground connection. Large amounts of noise or 60 hertz voltage on the instrument chassis may affect the accuracy of the readings. Be sure the power switch is OFF before inserting the line plug.

c. Power Line Voltage. The instrument is designed for operation on a line voltage of 105 to 125 volts AC. The unit will operate on 50, 60, or 400 hertz with no internal wiring changes required. Power consumption is 2 watts. A line fuse is located inside the cabinet. See figure 12.

2.2 Operating Controls

The controls and terminals located on the front panel are described below. These are the controls used in the normal operation of the Thermal Transfer Voltmeter. The internal controls and adjustments used in the calibration of the instrument are covered in the appropriate maintenance section of this manual.

a. ON-OFF Switch. This switch turns on the indicator light, null detector, internal reference and balancing source. The Model 6A employs a highly stable reference diode to stabilize the power supply used in the balancing circuits. It is recommended that the unit be switched OFF only for those extended periods when it will not be in use or when it is being stored.

NOTE

When the unit is first turned on, allow 30 minutes warm-up time before attempting to make accurate measurements. Extremely good long term null stability (0.01% per hour) can be expected if the unit is left ON rather than warmed-up each time it is used.

b. Zero Adjust. This control is used to zero or center the null detector meter. It should be adjusted prior to each high accuracy reading. Under ordinary conditions the meter may require some adjustment during the first half hour of operation, thereafter only minor adjustments should be required.

c. Function Switch. This three position switch controls the input circuit connections. In the DC position, the input circuit is connected to the two DC input binding posts on the left. In the AC position, the input circuit is connected to the AC input connections on the right. In the STANDBY position, the input circuit is connected to neither set of terminals. The STANDBY position is also used when the Model 6A is used for current measurements and the current shunt connector is in use.

WARNING

Do not attempt to switch the FUNCTION switch from the AC input position to STANDBY if the input voltage exceeds 500 VAC at frequencies greater than 50 kHz. Decrease the input voltage to below 500 VAC before switching under these conditions.

d. Voltage Range Switch. This 15-position switch allows selection of one of the 14 full scale ranges at which the Model 6A will operate. Each voltage range is usable from 50% to 100% of the full scale voltage value. The first position of the range switch provides for operation from the current shunt connection for current measurement.

e. Sensitivity Buttons. The three sensitivity buttons are marked SEARCH-COARSE, MEDIUM, and FINE. Depressing a button connects a difference voltage from the thermoelements to the null detector and controls its relative sensitivity. The SEARCH-COARSE button is the least sensitive range and should be used when starting to null a new voltage to prevent overdriving the null detector. If two or more buttons are depressed together, the most sensitive button will supersede. Depressing a button and turning it clockwise approximately 1/2 turn will lock it in a DOWN or ON position. Rotating the button counterclockwise will release it and place it in an OFF position.

f. Balance Controls. The three balance controls are marked SEARCH-COARSE, MEDIUM, and FINE. Each control is used to null a difference potential as indicated on the panel meter. The SEARCH-COARSE control consists of a two section switch with concentric shafts and separate index mechanisms. Fixed resistors are connected between contacts. Resistance values are chosen to assure adequate total resistance overlap of the COARSE control when compared to the single step

resistance of the SEARCH control. The MEDIUM and FINE controls are wire wound potentiometers. These four controls vary in sensitivity and should be used with the correspondingly marked sensitivity buttons. For example, with the SEARCH-COARSE sensitivity button depressed, the meter is nulled using the SEARCH-COARSE balance controls. Always null to within 1/2 of 1 major division on the meter before switching to the next more sensitive range.

To adjust the internal reference voltage to approximately 100% of the indicated voltage on the voltage range switch, rotate the two controls SEARCH-COARSE to the extreme counterclockwise position. The two controls are now in the zero position. Rotate the COARSE control to the second position. Rotate the MEDIUM and FINE controls so that the dots on the knobs are aligned with the corresponding dots on the panel.

To null an unknown voltage, set the Voltage Range Switch to a range well above the expected magnitude of the unknown voltage; depress the SEARCH-COARSE sensitivity button; place the Function Switch in the appropriate position. The null detector panel meter will indicate an extreme left deflection. (If the overload relay disengaged, a higher voltage range setting should have been selected. Switch to STANDBY, select a higher voltage range, reset the overload relay and continue.) Rotate the voltage range switch counterclockwise, pausing about five seconds at each position. When the meter deflection moves from the extreme left deflection or right deflection, the Model 6A is set to a range in which a null can be obtained.

g. Sensitivity Test. The three sensitivity test keys are marked 1%, 0.1%, and 0.01%. This is a convenient meter calibration under all balance conditions. To convert any given meter deflection to some known % per division, press the appropriate sensitivity key for the sensitivity range being used and note the null detector deflection. Apply the formula below or consult Table I.

h. Overload Reset. The overload reset button will automatically pop up with an audible click when the Model 6A is subjected to overloads in excess of 130% to 250% of any given range. Reset the overload relay by removing the overload (turn the function switch to STANDBY) and depressing the overload reset button until it clicks into place.

CAUTION

Attempting to reset the overload relay without first removing the overload may damage the instrument. Always set the function switch to STANDBY when resetting overload relay. It is recommended that the overload relay be released and reset several times prior to use each day to eliminate residual contact resistance problems which may cause small inaccuracies when making measurements.

$$\frac{\text{Sensitivity Test Key (\%)}}{\text{Resultant Galvanometer Deflection (Divisions)}} = \text{\% Resolution Division}$$

Meter Deflection (Divisions)	Resolution (%/Division)		
	1%	0.1%	0.01%
1	1.0	.1	.01
2	.05	.05	.005
3	.033	.033	.0033
4	.025	.025	.0025
5	.02	.02	.002
6	.0167	.0167	.00167
7	.0143	.0143	.00143
8	.0125	.0125	.00125
9	.0111	.0111	.00111
10	.01	.01	.001
11	.091	.0091	.00091
12	.083	.0083	.00083
13	.077	.0077	.00077
14	.071	.0071	.00071
15	.067	.0067	.00067
16	.0625	.00625	.000625
17	.0588	.00588	.000588
18	.0555	.00555	.000555
19	.0525	.00525	.000525
20	.05	.005	.0005
21	.0475	.00475	.000475
22	.0455	.00455	.000455
23	.0435	.00435	.000435
24	.0417	.00417	.000417
25	.04	.004	.0004

Meter Deflection (Divisions)	Resolution (%/Division)		
	1%	0.1%	0.01%
26	.0384	.00384	.000384
27	.037	.0037	.00037
28	.0357	.00357	.000357
29	.0344	.00344	.000344
30	.0333	.00333	.000333
31	.0323	.00323	.000323
32	.0312	.00312	.000312
33	.0303	.00303	.000303
34	.0294	.00294	.000294
35	.0286	.00286	.000286
36	.0278	.00278	.000278
37	.027	.0027	.00027
38	.0263	.00263	.000263
39	.0256	.00256	.000256
40	.025	.0025	.00025
41	.0244	.00244	.000244
42	.0238	.00238	.000238
43	.0233	.00233	.000233
44	.0227	.00227	.000227
45	.0222	.00222	.000222
46	.0217	.00217	.000217
47	.0213	.00213	.000213
48	.0208	.00208	.000208
49	.0202	.00202	.000202
50	.02	.002	.0002

Example: Assume you have nulled an unknown voltage and now observe a change of 5 divisions on the meter. To convert this change to percent of the applied voltage, depress the .1% key (assuming you are on the FINE sensitivity range) and note the meter deflection. Assume it is 33 divisions. The formula above gives:

$$\frac{.1\%}{33 \text{ divisions}} = .003\% \text{ per division}$$

The use of Table I gives .00303. Hence the 5 division change originally observed is equal to .00303 x 5 or .015%.

i. Input Terminals. The group of five way binding posts on the left are the DC voltage input terminals. The red terminal is positive. The lower black terminal is floating negative or common. Connections should be made to similar terminals on the DC voltage source. The outside black terminal is chassis ground.

WARNING

COMMON MODE LIMITATIONS

The ground strap is provided for the elimination of ground loops when making precision measurements. The instrument should never be connected in a circuit where there is an excessive voltage between the common terminal and the chassis terminal. A safe maximum limit would be ± 10 VDC or 3 VAC. DC reversal measurement requires the use of a source which can be isolated from ground.

The terminals on the right are the AC voltage input connections. These terminals will accept either a UHF shielded plug or a double banana plug. The metal lower receptacle, as well as the outside of the UHF receptacle, is connected to the chassis and should be connected to the common, low, or grounded side of the AC source.

j. Current Shunt Terminal. This is a UHF receptacle designed to accept the Holt HCS-1 Current Shunts for current measurements up to 20 amperes. Refer to the HCS-1 Current Shunt Manual or consult the Holt engineers for details on use, operation, and applications of the shunts.

k. HFTC Receptacle. This three terminal receptacle is designed to accept the High Frequency Thermocouple Assembly (Holt Part Number 82770). This cable permits use of the Model 6A with the Holt Model 20 Thermal Voltage Converters to extend the use of the Model 6A up into the 30 megahertz region.

NOTE

The HFTC receptacle is provided with a shorting plug and screw-on cap. This shorting plug completes the connection to the internal thermoelement and must be in place whenever the Model 6A is used for any purpose not requiring the use of the HFTC receptacle.

2.3 Applications

a. General. The primary function of the Model 6A is as a transfer device wherein the reference level is first set to conform to some unknown AC input voltage and then compared to an identical DC input whose magnitude is known or can be accurately measured. The Model 6A requires certain external equipment as follows:

(1) DC Supply. A stable DC supply with variable output voltage is required.

(2) DC Measuring Equipment. The accuracy with which the DC voltage can be measured is a determining factor in the accuracy of the system. A standard cell, voltbox, and potentiometer system is recommended.

(3) AC Supply. A stable, adjustable, variable frequency supply such as the Holt Model 325A is required if calibration and frequency response measurements are to be conducted.

A few of the more common applications of the Model 6A and this external equipment are detailed below.

b. Voltage Measurement. A diagram of a typical calibration circuit is shown in figure 3. The AC voltage to be measured is applied at the AC input terminals of the Model 6A and is also applied to the instrument under test. The voltage range switch is set to the range to be calibrated and the function switch is set to AC. The SEARCH-COARSE sensitivity button is depressed and the SEARCH-COARSE balance control adjusted to give a null on the meter. The process is repeated using the MEDIUM and then FINE buttons and controls. Switch the function switch to the DC position and, without touching the Model 6A balance controls, adjust the DC source voltage until a null is again achieved. Measure the resulting DC voltage by accepted laboratory methods (potentiometer, voltbox, and standard cell).

Record the value of the DC voltage. Switch the VOLTAGE RANGE switch to AC and check to see that the original null has not drifted. Reverse the polarity of the DC voltage and switch to DC. Adjust the DC voltage to obtain a null without touching the BALANCE controls. Measure the value of the DC. Switch to AC and check to see that the AC null has not drifted. If there is no drift, the RMS value of the AC signal is determined by this formula:

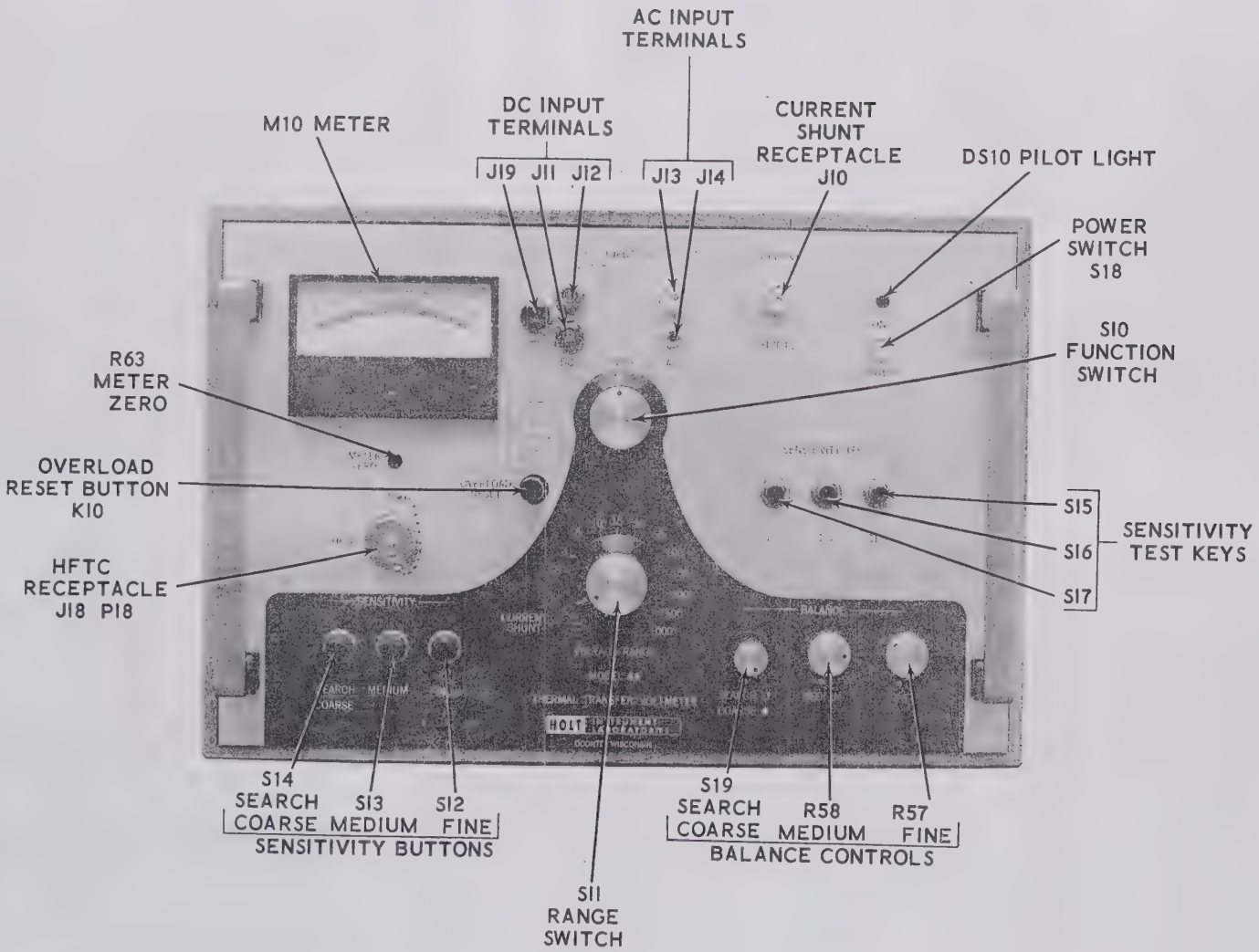


Figure 2. Operating Controls and Terminals

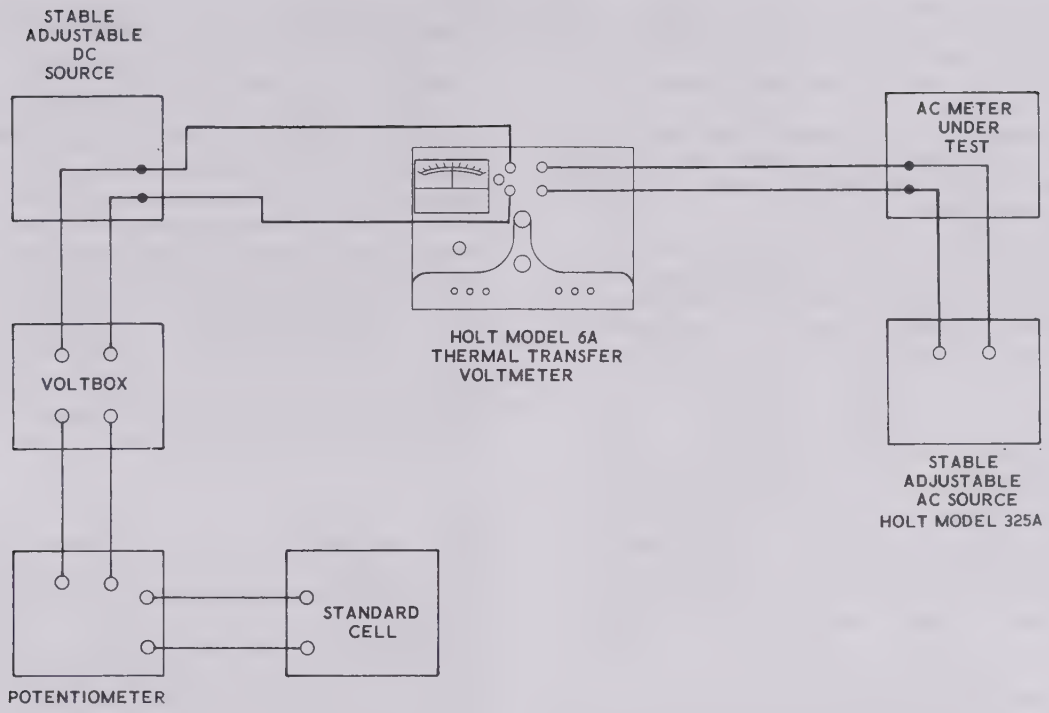


Figure 3. Typical Test Set-up for Model 6A Thermal Transfer Voltmeter

$$E_{RMS} = \frac{E_{+DC} + E_{-DC}}{2}$$

It is essential to make the transfer measurement in a short time to eliminate errors due to drift in either the AC source or the other instrumentation. For greatest certainty of measurement, the total transfer measurement should be made at least twice to eliminate any errors due to drift or technique.

NOTE

At lower voltage ranges, the voltage drops across connecting leads can add significant error to the measurement. It is recommended that lead lengths be minimized and symmetrical. Test the leads by connecting both pairs to the same terminals of a stable supply and removing the ground link on the Model 6A. In the DC position, null by adjusting the balance controls. Release key, switch to AC position and meter should again null. If it does not null, correct lead resistance by changing lengths, until a null is obtained. Connect the voltbox to the DC source with the DC leads from the Model 6A. Connect the AC leads to the instrument or AC supply under test. Figure 3 shows a typical test set up.

CAUTION

If the AC instrument under test draws appreciable current, care should be used to reduce contact resistance or use four terminal procedure.

c. Relative Frequency Response Measurements. These measurements can be made using the same circuit and techniques as for voltage measurements (b.) above. Set the variable AC source to some midband frequency (400 Hz-1000 Hz). Adjust the AC source to give a full scale reading on the device under test. Null the Model 6A as above. Now change the frequency of the source to a new frequency, adjust the output of the AC source to again give a full scale reading. The resulting deflection of the Model 6A is the response of the device under test relative to the midband frequency within the accuracy of the Model 6A.

d. Current Measurements. (Require the use of HCS-1 Shunts.) Connect the proper shunt to the current shunt terminal. Set the function switch to the STANDBY position and the range switch to the CURRENT SHUNT position. Balance the Model 6A using the same procedure as in Voltage Measurements (b.) above. Refer to the Holt HCS-1 Current Shunt manual for details on the use, operation, and application of the shunts.

When using the Model HCS-1 20 ampere current shunt with the Model 6 (or the Model 6A) operating in the CURRENT SHUNT mode, it is not possible to obtain a null for currents greater than 20 amperes. The current range can be extended to 26 amperes by plugging the shunt into the AC INPUT terminals and switching the FUNCTION switch to the AC position and the VOLTAGE RANGE switch to the 1.5 volt position.

e. High Frequency Measurements. (Requires the use of the High Frequency Thermocouple Cable No. 82770 and the proper Model 20 Module.) Remove the cap and jumper plug from the HFTC receptacle on the Model 6A. Insert the High Frequency Thermocouple Cable between the Model 6A and the proper Model 20 Module. Null the meter using the same procedures as in voltage measurements (b.) above. Refer to the Model 20 manual for details of use, operation, and applications of the Model 20 modules.

NOTE

The cap and jumper plug must be reinserted into the HFTC receptacle before the Model 6A is used in other measurements.

SECTION 3
THEORY OF OPERATION

3.1 General Theory

a. The fundamental theory upon which the Model 6A is based is that the RMS value of an alternating current has exactly the same heating effect as a like value of direct current. Thus, if a thermoelement junction is heated with an unknown value of AC and the temperature of the junction is sensed, it is a relatively simple matter to reheat that same junction to precisely the same temperature with a DC voltage and then measure the DC voltage accurately by means of a standard cell, voltbox, and potentiometer. Based on the theory above, the AC and DC values would be identical.

b. The heart of the Model 6A is the vacuum thermoelement. This consists of a heater or heating element with a standard thermocouple junction attached to the heater with a small glass bead. The complete assembly is sealed in an evacuated container. The thermocouple senses the temperature of the heater and generates a voltage proportional to the temperature of the heater. The thermoelement is a low current device and is very sensitive to overload. In order to broaden the operating range of the thermoelement suitable limiting resistors are employed to limit the currents to the values required to heat the junction without overload.

3.2 Basic Circuit Theory

a. The block diagram (figure 4) illustrates the relationship of the five circuits that make up the Model 6A. The AC input from the function switch is applied to an input circuit. This input circuit is primarily an adjustable voltage dropping resistor to reduce the voltage to the low limits required by the input thermoelement. A protection circuit, connected between the input and thermoelement, serves to protect the input thermoelement in the event of overload. The output voltage of the input thermoelement is connected in opposition or differentially with the output voltage of the balancing thermoelement. The input voltage is applied to the input thermoelement and nulled by voltage from the balance circuit which is applied to the balance thermoelement. Balance between the two thermoelements is detected by the null detector supplies through the null indicating circuit. The null indicating circuit is a shunt arrangement to control the sensitivity of the null detector.

b. The paragraphs that follow will each be devoted to a discussion of the operating theory of one of the basic circuits that make up the Model 6A. Refer to the block diagram (figure 4), the simplified schematics or the complete schematic at the end of the text to better understand the function of each circuit and its use in the Model 6A.

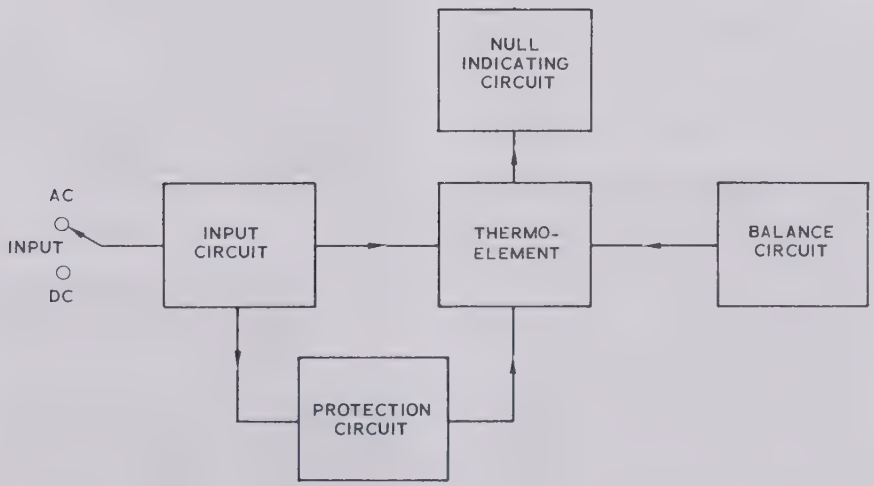


Figure 4. Block Diagram of the Model 6A

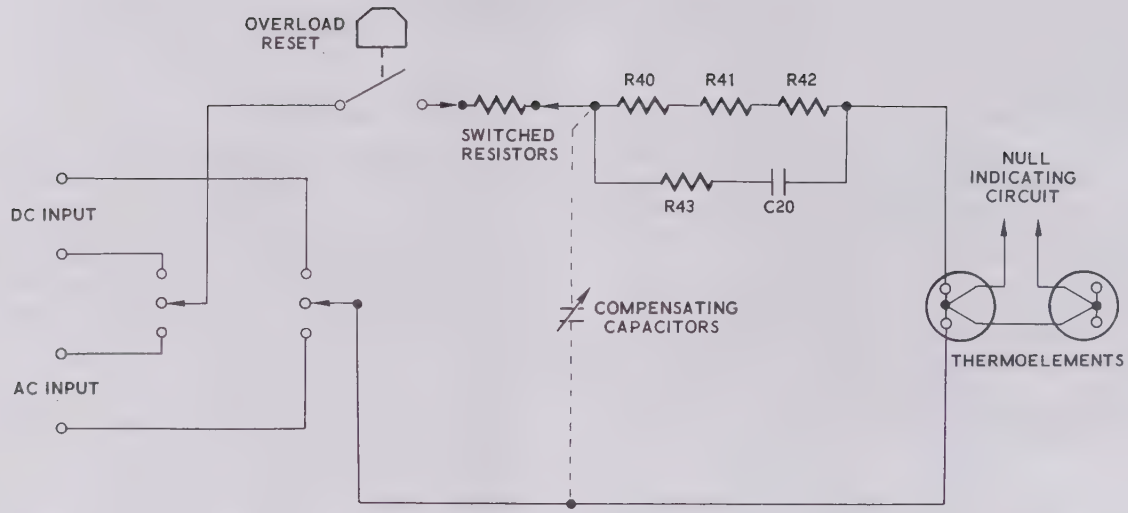


Figure 5. Input Circuit for Voltage Measurements

3.3 Input Circuit

a. Voltage Measurements. The simplified schematic illustrating the input circuit used for voltage measurements is diagrammed in figure 5. Actual operation of the Model 6A would require only one set of input terminals. However, since it is desirable to provide for rapid transfer between AC and DC inputs to prevent thermoelement cooling, a pair of terminals are supplied for AC and another pair for DC. An internal function switch permits rapid selection of either AC or DC inputs. This switch and the wiring between the switch and input terminals are the only portions of the circuit which change between AC and DC measurements. Changes in the characteristics of the switch and circuit must be extremely small. The Model 6A employs parallel solid silver switch contacts and heavy solid buss wire connections in the input circuit to insure low and repeatable resistances, and symmetrical current paths.

From the function switch the input signal passes through the contacts of the overload relay. The action of this relay will be discussed in the theory of operation of the protection circuit (par. 3.4). With the overload relay in the normal closed position, the input signal is applied to the range switch. This switch selects the proper range resistor for the full scale voltage range required. These resistors are selected for good temperature coefficients to prevent drifting or wandering due to self-heating. They have good frequency response characteristics so that errors over the frequency range of the instrument are extremely small and they are capable of withstanding voltages of as much as 1000 volts for short periods in the event of severe overloads. The output from the selected range resistor is then applied through a very low impedance compensation network to the input thermocouple. This network is designed to compensate for a very small amount of inherent inductance in the thermoelement. This compensation network permits operation at very low voltages out to 1 megahertz.

On the higher voltage ranges, small amounts of capacity appear across the high impedance range resistors. To compensate for this capacity, fixed capacitors are bridged across the thermocouple on the 100 and 150 volt ranges while an adjustable trimmer is used on each of the three highest ranges (300, 500, and 1000 volts). In the upper three ranges the positioning of the range resistors and wiring produces some variation in capacity from unit to unit. The trimmers allow for rapid factory compensation of this variation without the need for selection of components.

The input thermoelement is unique in that it is actually a pair of thermoelements wires in such a manner so as to reduce the DC reversal error to well below 0.01%. These thermoelements are specially selected by Holt Instrument Laboratories for this particular application.

b. Current Measurement.

NOTE

Current measurements require the use of Holt HCS-1 current shunt manual for application information on these devices.

The internal connections of the Model 6A when set up for current measurements are shown in figure 6. The external shunt is connected to the current shunt terminal. The function switch is placed in the STANDBY position and the Range Switch in the CURRENT SHUNT position. This completes the internal connections as shown in figure 6. Essentially the circuit consists of a 100 ohm current limiting resistor in series with the thermocouple. The same compensating network and protective relay is used as for voltage

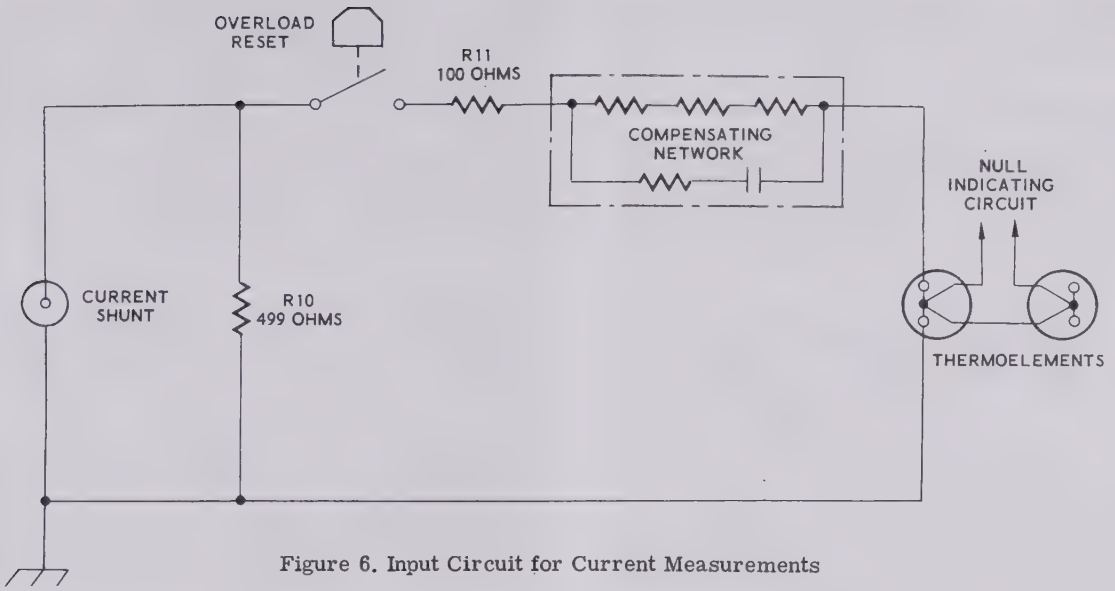


Figure 6. Input Circuit for Current Measurements

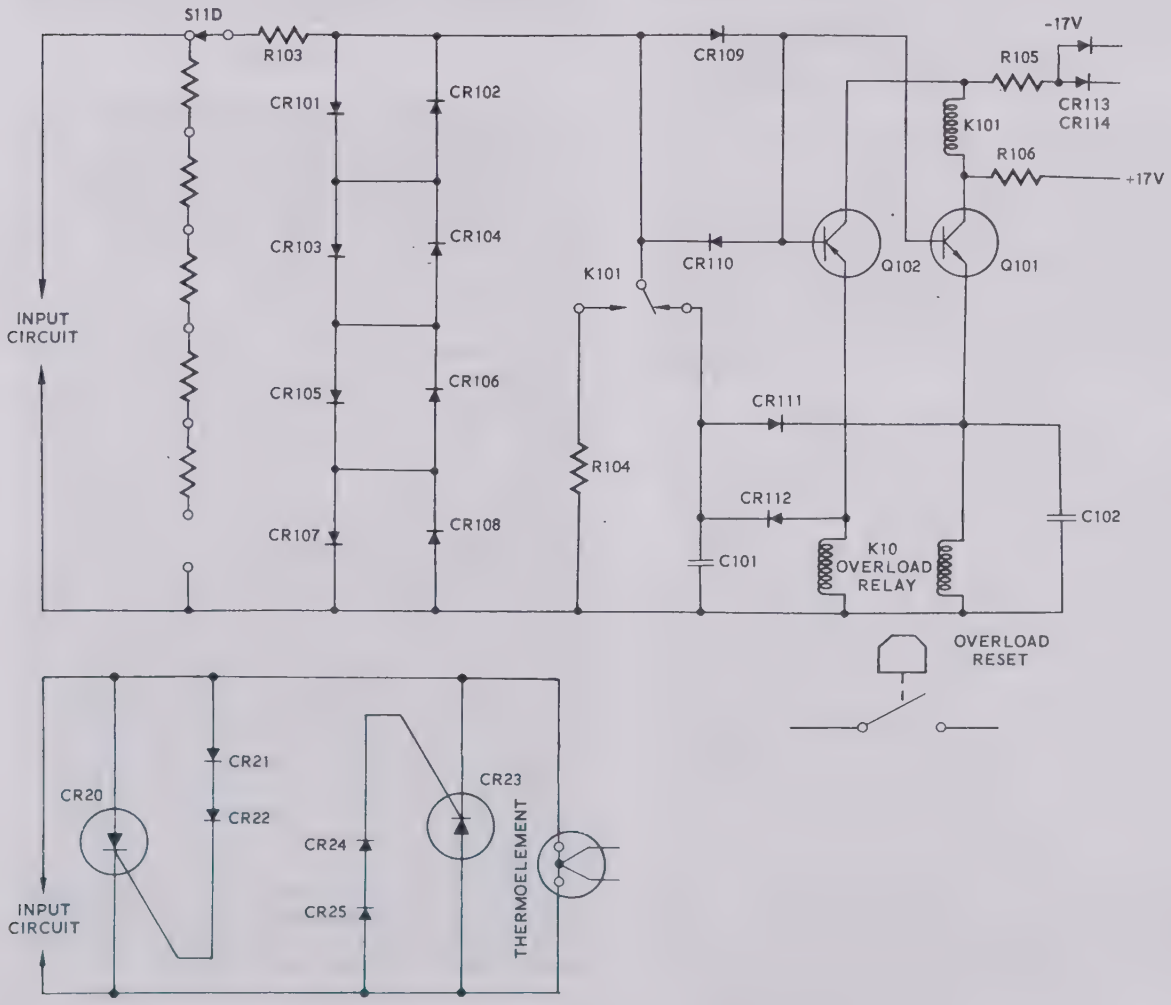


Figure 7. Protective Circuits

measurements. A resistor (R10) is connected across the input to change the input impedance to match the HCS-1 shunts.

3.4 Protective Circuits

a. General. There are two protective circuits employed in the Model 6A. The first is a solid state circuit that is connected directly across the input thermocouple; the second is the overload relay. These two circuits are each described below and are illustrated in figure 7.

b. Solid State Protective Circuit. The solid state protective circuit consists of two silicon controlled rectifiers (CR20 and CR23) and four small diodes (CR21, CR22, CR24, and CR25) connected directly across the input thermocouple. See figure 7B. The silicon controlled rectifiers (SCR) and diodes are arranged in two back-to-back circuits. This arrangement provides protection against overloads on both polarities of DC as well as on both half cycles of any applied AC. The SCR's act as solid state switches which are normally off and present a high impedance to any applied voltage. The diodes are connected into the gate circuit of the SCR's and are essentially connected directly across the thermocouple. The diodes also offer a high impedance to low level signals appearing across the thermocouples. When the voltage across the thermocouple increases and reaches the Fermi conduction level of the diodes (1.4 volts), current through the diodes increases rapidly. This current flowing through the gate circuit fires the SCR's. When the SCR is fired, it presents practically a short circuit to any applied voltage and essentially clamps the voltage across the thermocouple at 0.7 volt. The SCR's are selected to handle large amounts of current for very short periods. The high current through the SCR's will be of short duration, since the overload relay will function to open the circuit in 30 to 100 milliseconds.

c. Overload Relay Circuit. The overload relay circuit senses the input voltage and opens the input circuit in the event of any long term overload, thus protecting the range resistors, range switch, wiring and silicon controlled rectifiers. The input circuit is sensed by a resistive attenuator (R90 to R25) connected across the input terminals. See figure 7A. This attenuator is a part of the range switch and is so wired that its output voltage is approximately 1/2 volt when full scale voltage is applied to the input terminals. The output from the attenuator is applied to the relay amplifier. The relay amplifier activates the overload relay when its input signal is sufficient to overcome the forward conduction voltages of the diode-transistor combinations. Complementary transistors are used so that the relay amplifier will respond to both polarities of DC as well as AC inputs. Use of the amplifier limits the current through the relay coil to a small value until the voltage applied to the input circuit of the Model 6A reaches 120% to 250% of the rated range voltage. When the voltage exceeds this limit, the amplifier closes the relay and the input circuit is opened (see complete schematic at the rear of the manual). Once the overload relay has been tripped, the overload must be removed (this is best done by switching to STANDBY) and the overload relay must be reset manually by pressing the reset button on the front panel. The large capacitors (C101 and C102) across the overload relay coil permits operation of the relay circuit at all frequencies within the range of the instrument.

In the event an overload is applied to the instrument when it is not operating relay K101 will apply the overload signal directly to the overload relay via diodes CR111 and CR112. This will activate the overload relay and again remove the overload signal from the critical circuits. Diodes CR101 through CR108 limit the overload signal to the relay amplifier to prevent damage to this circuit.

d. Summary. In the event of an overload that might damage the thermocouple, the silicon controlled rectifiers will instantly trigger and bypass the thermocouple, thus protecting it from burnout. The SCR's will carry the high overload current for a period of 30 to 100 milliseconds at which time the overload relay will operate and open the input circuit removing the overload.

CAUTION

Be sure to remove the overload by turning the function switch to STANDBY position before attempting to reset the overload relay. Failure to do so may result in damage to the range switch, range resistors, etc.

3.5 Balance Circuit

The balance circuit is essentially a second thermocouple, connected in opposition to the input thermocouple, driven through a current limiting circuit from a reference diode stabilized power supply. See the complete schematic at the rear of the manual. The four balance controls are variable resistances and are connected in series. The FINE control (R57) is a two ohm potentiometer. The MEDIUM control (R58) is a 40 ohm potentiometer. Both of these controls are single turn, wire wound potentiometers selected for good temperature coefficients and fine resolution. The SEARCH-COARSE balance controls consist of a two section switch with concentric shafts and separate index mechanisms. Fixed resistors are connected between contacts. Resistance values are chosen to assure adequate total resistance overlap of the COARSE control when compared to the single step resistance of the SEARCH control.

The fixed resistors (R47 and R89) connected in series with the thermocouple and balance controls merely set the maximum and minimum range of current to be determined by the four balance controls. This resistor (R89) is provided to match the circuit to any thermocouple since there are some small variations between thermocouples.

The remainder of the balance circuit consists of the test sensitivity keys and their associated resistors. This circuit is a constant impedance network that shunts predetermined percentages of current around the thermoelement. The portion of current shunted around the thermoelement is determined by which key is depressed. The three keys give a choice of 1%, 0.1%, or 0.01%. By diverting a given percentage of the total current around the thermoelement, a change in output by the same percent can be noted on the meter.

3.6 Null Indicating Circuit

The null indicating portion of the circuit is the most sensitive area in the Model 6A with respect to temperature and thermal EMF's. The voltages measured here are extremely low and any voltages introduced by thermals will result in rather large errors. For this reason, the circuitry in this area is heat sinked to large aluminum blocks to prevent the rapid change in temperature of any soldered junction which might generate these thermal EMF's. The sensitivity buttons in this portion of the circuit are also chosen to provide low thermal EMF contributions.

The null indicating circuit consists of two resistors and three sensitivity buttons. See the complete schematic at the rear of the manual. The output of the two thermoelements, connected in opposition is supplied to this network through the HFTC shorting plug. The circuit is arranged to connect the null detector directly with the FINE button depressed, to shunt the null detector to less sensitive levels when the SEARCH-COARSE and MEDIUM buttons are depressed.

When the cap and shorting plug are connected to the HFTC receptacle, the circuit will function as described. Removal of the cap and shorting plug removes the input thermoelement from the circuit. The insertion of the adapter cable and HFTC module merely replaces the input thermoelement with the thermoelement in the Model 20 HFTC module. This substitution allows use of the balancing thermoelement in the Model 6A and its associated balance and null indicating circuits in reading out the HFTC modules.

NOTE

The HFTC cap and shorting plug must be in place in the HFTC receptacle any time that the Model 6A is in use except with the HFTC adapter cable.

The input and balancing thermoelements are mounted in a common heat sink so that the ambient temperature is reflected equally in both thermocouples, thus compensating to some degree for ambient temperature variations. The heat sink also provides a thermal lag from rapid ambient changes and maintains a relatively constant temperature around both thermocouples.

The input thermoelement is actually made up of two selected thermoelements connected in such a manner as to reduce the DC reversal error to less than 0.01%. The balance thermoelement is a single unit of standard construction. The two thermoelements are connected in opposition to each other so that when heated to a balance point the output is zero. See the complete schematic at the rear of the manual for the thermoelement connections.

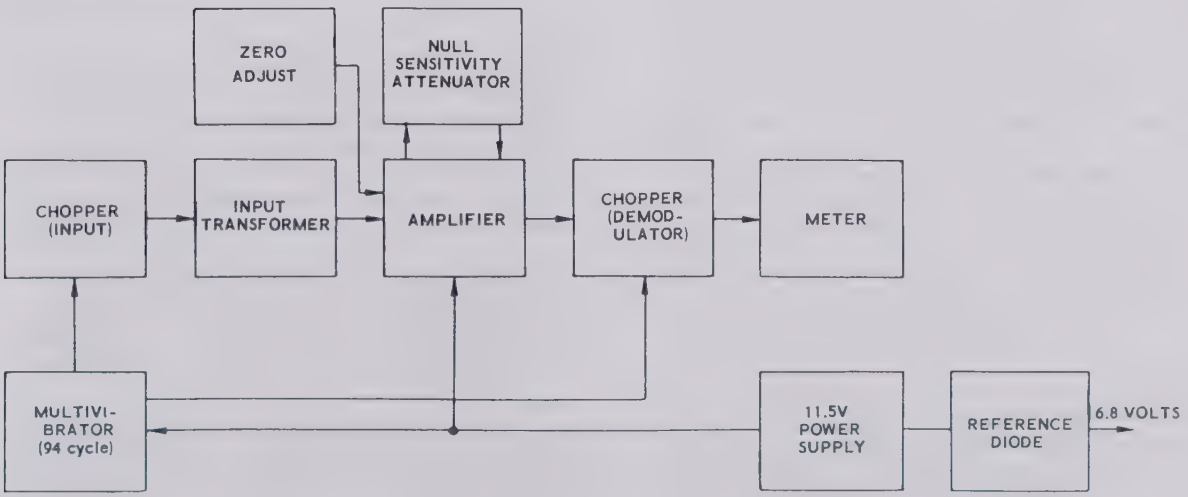


Figure 8. Null Detector Block Diagram

3.7 Null Detector

a. General. The null detector consists of a meter and two printed circuit boards. Figure 8 illustrates a block diagram of the null detector.

Input to the null detector is applied to one set of contacts on a mechanical chopper. The chopper is powered by a 94 Hertz multivibrator. This arrangement provides excellent line isolation. Output from the chopper is fed through an isolation transformer to the chopper amplifier. The chopper amplifier is gain stabilized with feedback and provides a sensitivity of 5 microvolts full scale. Output of the amplifier is demodulated by the second section of the chopper operating as a synchronous demodulator. The resulting DC is applied to the null detector meter.

b. Power Supply and Chopper Drive Circuit Board. Refer to the schematic diagram. Line voltage is applied to the primary of power transformer T801. The secondary voltage is rectified and regulated by transistor Q801, a series pass regulator. Output of the regulator circuit is sensed at the arm of R813. Adjustment of this sets the regulated output at +10.5 volts DC. Transistors Q804 and Q805 make up a differential amplifier that compares the output voltage to the voltage across zener diode CR803. The difference or error voltage is amplified by Q803 and Q802 and is used to control the series pass regulator.

The four transistors Q806, Q807, Q808, and Q809 make up a free running multivibrator that supplies a 14 volt peak-to-peak 94 Hertz signal to operate chopper G901, located on the amplifier board. Frequency is adjusted by potentiometer R825. Resistor R63 is a front panel control - the METER ZERO control, and it supplies some chopper drive signal to the amplifier. The phase of the signal is adjusted by the control as required to zero the null detector meter.

c. Amplifier Circuit Board. Refer to the schematic diagram. The input to the null detector is the difference voltage generated by the two thermoelements in the Model 6A. This very small output voltage is connected to the chopper G901 and to the center tap of transformer T901. The secondary provides an AC signal to the bases of transistors Q901 and Q902.

The AC signal varies in phase and magnitude with the difference voltage from the thermoelements. The outputs of transistors Q901 and Q902 are fed to a differential amplifier consisting of transistors Q903 and Q904. Output of this amplifier is connected to another differential amplifier consisting of transistors Q905 and Q906. It is then amplified by a pair of common emitter amplifiers (Q907 and Q908). An emitter follower, transistor Q909, drives the output half of the chopper. The chopper acts as a synchronous demodulator and the resulting DC signal is filtered by C911 and C912 and supplies the meter M10. Control R926 acts as a gain control for the circuit by varying the negative feedback to Q906.

3.8 Power Supply

The null detector circuit is powered by a self-contained 10.5 volt DC power supply. Power to operate the balance circuits is supplied from the same source. A reference diode (CR901) and a series resistor (R931) connected to the 11.5 volt DC source deliver a stabilized 6.8 volts DC to operate the balance circuit. The reference diode is selected at the factory to stabilize the voltage within 5%.

SECTION 4
RECALIBRATION

4.1 Recommended Test Equipment

When performing the maintenance and calibration checks as described in the following paragraphs, the following test instruments, or instruments of similar quality, should be used.

a. When calibrating the null detector (par. 4.2), the following equipment is required:

Oscilloscope	Laboratory Type
Frequency Counter	Beckman Model 5230 BP
DC Voltmeter	11 megohm input, 3% accuracy
DC Supply	Kintel Model 304

b. When performing periodic maintenance tests (par 4.3), the following equipment is required:

DC Supply	Kintel Model 304

c. When calibrating the Model 6A subsequent to repairs (par. 4.4), the following equipment is required:

Wheatstone Bridge	Otto Wolff 944
DC Supply	Kintel Model 304
DC Voltmeter	11 megohm input, 3% accuracy

d. When required, frequency response calibrations of the upper ranges would require AC sources and high frequency thermal converters not generally available at this writing. Holt Instrument Laboratories has constructed a special test console to provide AC voltages from .5 volts to 1000 volts at frequencies from 5 hertz to 1 megahertz. Likewise, special calibrated comparison standards have been designed and are used in the Model 6A calibration. Contact Holt engineers in the event that frequency response calibration should be required.

4.2 Null Detector

Calibration of the null detector will be required only at infrequent intervals. If excessive fluctuations are noted on the null detector meter or if readings do not repeat, check the null detector calibration procedures in the order given below. (Excessive fluctuation of the meter is defined as more than ± 1-1/2 minor divisions peak to peak.) Location of controls and terminals on the null detector circuit boards are illustrated in figure 12.

a. Voltage. Connect a DC voltmeter between terminals 11 and 12 on the null detector board. (Terminal 11 common.) Adjust the VOLTAGE control for a reading of 10.5 volts (± 0.1 volt).

b. Frequency. Connect a frequency counter to terminals 8 and 11 (terminal 11 common) on the null detector board. Adjust the FREQUENCY control for 94 hertz (± 1 hertz).

c. Gain. Connect a DC supply to the input terminals of the Model 6A. Adjust the supply to deliver 100 volts. Null the Model 6A. Change the power supply voltage by .05 volts. Meter should move full scale (± 1 major division). If a full scale movement does not occur, adjust the GAIN control to give a full scale reading.

d. Feedback. The FEEDBACK control is a factory adjustment and should not be readjusted in the field.

4.3 Periodic Maintenance

Adjustment for 50 to 100% Range Coverage. If, for any reason, the full 50 to 100% of a given range cannot be balanced, remove the Model 6A from its cabinet. Remove the inner shielded case. Connect a DC source to the DC input terminals and adjust for some full scale reading. Set the function switch to DC and the range switch to the appropriate range. Set the FINE and COARSE balance controls to the dots on the panel (mid-range). Vary the DC source voltage and check the range coverage with the search balance control. Balance should be obtained at 105% plus with the SEARCH control full counterclockwise and at 45% with the control clockwise. Adjust R55 until operation is secured over the complete range. Replace the inner shield case and cabinet.

4.4 Calibration Subsequent to Repair

a. General. The following procedures are not periodic in nature and would be required only in the event replacement of protection circuitry, range resistors, thermoelements, or associated wiring appeared to be required. Set the controls of the Model 6A as follows: Power Switch OFF, sensitivity keys unlocked and up, HFTC cap in place, function switch in STANDBY, overload button reset, range switch in CURRENT SHUNT position. Set both the SEARCH and COARSE balance controls extreme counterclockwise. Rotate the COARSE control clockwise to the second position. Set each of the other balance controls so that the dot on the knob is lined up with the dot on the panel. Unsolder the jumper wire shown in figure 14 and resolder it to short the center terminal to the terminal connected to R88. Make the following indicated tests.

b. Range Resistors. Measure the resistance from the center of the current shunt terminal to the front panel. Reading should be 136 to 150 ohms. Place the function switch in DC position and the range switch as indicated below. Resistance between the DC terminals should be as follows:

Range	Resistance
.5 V	84 - 102
1 V	171 - 201
1.5 V	259 - 299
3.0 V	522 - 592
5.0 V	875 - 975
10.0 V	1765 - 1975
15.0 V	2.73 K - 3.45 K
30 V	5.4 K - 6.02 K
50 V	8.8 K - 9.8 K
100 V	17.6 K - 19.6 K
150 V	26.4 K - 29.4 K
300 V	52.8 K - 58.5 K
500 V	88 K - 98 K
1000 V	190 K - 210 K

c. Protection Circuit-Solid State. To check the operation of the solid state protection circuit, set the controls on the Model 6A as described in (a.) above. Open the contacts of the overload relay and connect a short jumper across the contacts. This will effectively bypass the overload relay. Connect a variable DC source of 1 to 2 volts across the DC input terminals. Set the function switch to DC. Set the range switch to the 0.5 volt range. Connect a DC voltmeter with a 1.5 volt range across the 91 ohm dummy thermoelement load resistor. Increase the input voltage in tenth volt increments from 1 volt. At some voltage before 1.5 volts, the silicon controlled rectifiers protecting the thermoelement should fire, clamping the voltage across the 91 ohm load resistor at approximately 0.7 volt. Repeat the test with reversed DC input polarity. Results should be the same. Remove the jumper from the relay.

NOTE

Always return the input voltage to zero after each test in order to turn off the silicon controlled rectifiers.

d. Protection Circuit Overload Relay. POWER MUST BE ON BEFORE STARTING THESE TESTS. To check the operation of the overload relay, set the controls on the Model 6A as described in (a.) above. Set the range switch to the 1 volt range. Apply 1.2 volts DC to the DC input terminals. Set the function switch to DC. The relay should not trip. Set the function switch to STANDBY and change the applied DC voltage to 2.5 volts. Set the function switch to DC and the relay should trip.

CAUTION

Always remove the overload voltage in order to reset the overload relay. This can easily be done by switching the function switch to STANDBY.

With the 10 volt range selected, reset the overload relay and apply 100% of the range voltage. Test the holding power of the relay by switching the range control and subjecting the instrument to vibration and repeated shocks. A good protective relay will trip at 130% to 250% of range voltage and will hold solidly at 100%. Repeat the above tests with reversed DC polarity applied to the input. Check the AC operation of the circuit by application of a 50 kHz signal. The relay should trip between 130% and 250% of the range. If the relay does not function as described above, there are two adjustments possible. The first is located at the rear of the overload assembly and consists of a rotating permanent magnet in a holder. The second is a spring adjustment near the top of the relay. Both adjustments are normally sealed to prevent slippage. If changes are made to either adjustment, they should be made in very small increments and the results checked each time as described above. The adjustments are critical. Seal the adjustments when changes are completed.

NOTE

When all three of the above tests (b, c, and d) are completed and the protective circuit is operating properly, the jumper should be resoldered in its original position as in figure 14.

4.5 Frequency Response

a. General. The frequency response of the upper three ranges is adjustable with small shunt capacitors located below the range switch. See figure 9. This adjustment is made at the factory at the time of calibration and should require no further adjustment in the field. In the event of serious damage requiring the replacement of wiring or range resistors, this circuit may require readjustment. It is recommended that adjustment of this compensation be made only in the presence of certified standards if operation within the specifications is to be assured.

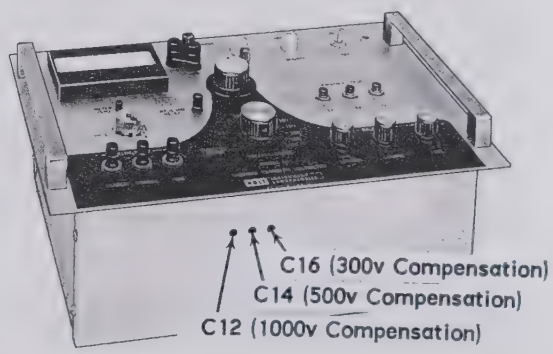


Figure 9. Location of Trimmer Capacitors

b. Adjustments. Adjust the frequency response on the upper three ranges as follows: Remove the outer cabinet but leave the inner shield case in place. The trim capacitors are accessible through three holes in the side of the shield. See figure 9. Calibrate the Model 6A with a standard at 1000 volts and adjust the trim capacitor C12 to give a response which is ± .04% maximum at 50 kHz and ± .02% maximum at 20 kHz. Calibrate the 500 volt range by adjusting the trim capacitor C14 to give a response which is ± 0.01% maximum at 50 kHz, within ± 0.01% of null at 20 kHz and within ± 0.2% at 100 kHz. Calibrate the 300 volt range by adjusting the trim capacitor C16 to give a response within ± 0.01% at 20 kHz and 50 kHz and within ± 0.2% at 100 kHz. Once this compensation is finished, the instrument should be read out to insure that the compensated high voltage ranges are within specifications, since there may be some interaction between ranges when compensating.

SECTION 5

SERVICING

5.1 Voltage Measurement

As a convenience for maintenance personnel, all the information required to troubleshoot the Model 6A is supplied on the schematic diagrams. This eliminates the tiresome paging required when voltage charts are used. Waveforms, when required, will also be found on the schematics.

5.2 Conditions for Voltage Measurements

The voltage measurements and the waveforms are all taken with the equipment operating under the conditions specified on the schematic diagram.

5.3 DC Voltage Measurements

All DC voltage measurements are printed in blue on the schematics. Readings are taken with a VTVM having an input resistance of 11 megohms. Readings are taken with reference to common. Values shown are ± 20% unless otherwise specified on the schematic.

5.4 AC Measurements and Waveforms

All AC measurements are printed in red on the schematics. Readings are all peak-to-peak values measured with a 10 megohm oscilloscope probe. All readings are taken with reference to common. Values shown are ± 10% unless otherwise specified on the schematic.

5.5 Component Locations

Components are labeled uniformly on schematics, parts lists, and illustrations. Location of a part can be determined by referring to the parts list. The number of the illustration showing the desired part is listed in the right hand column.

5.6 Servicing Precautions

There are a number of precautions which must be observed when servicing the Model 6A. They must not be violated or permanent damage to the instrument may result.

a. Never remove any transistor with power applied to the instrument.

b. Never substitute component types unless authorized by Holt Instrument Laboratories.

c. Be sure to install transistors properly in their sockets.

d. Do not use a solder gun which can damage the printed circuit boards or solid state devices because of excessive heat.

e. Do not attempt to use an ohmmeter to measure the heater resistance of the thermoelements. They will be damaged by the application of more than 0.5 volts or 5 ma.

5.7 Service Procedures

A standard procedure for servicing is recommended. Follow the sequence recommended below to properly maintain the Model 6A in the event of a suspected malfunction of the equipment:

a. Check front panel controls and external power supply to insure that the malfunction is within the instrument.

b. Perform the checks on the null detector, as detailed in paragraph 4.2, to determine if recalibration is required or if a servicing problem is present.

If the chopper appears to be the source of noise and instability, it may be due to contaminated contacts. Use the following procedure to clean the chopper contacts. Remove the power supply board from the null detector. Remove the chopper cover. Use an activated freon spray such as Miller-Stephenson MC-190 Flux remover to spray the contacts while the chopper is running. Spray for several seconds. After cleaning with the MS-190, flush generously with a non-activated freon spray such as Miller-Stephenson Contact Re-nu. Allow to drain and dry and replace the cover. These sprays cool the chopper and may cause temporary changes in alignment. Allow at least 1/2 hour for the chopper to reach normal temperature after cleaning.

c. Recalibrate according to paragraphs 4.3, 4.4, and 4.5, if required.

d. If a service problem is indicated in the preliminary checks, the checking procedure should give an indication of where the trouble may be located.

e. Refer to the proper schematics, parts location illustration and the theory of operation for the section to be tested. These sections should give all required troubleshooting information.

f. In the event of difficulties in maintenance or calibration beyond the limitations of the servicing agency, contact Holt Instrument Laboratories for instructions.

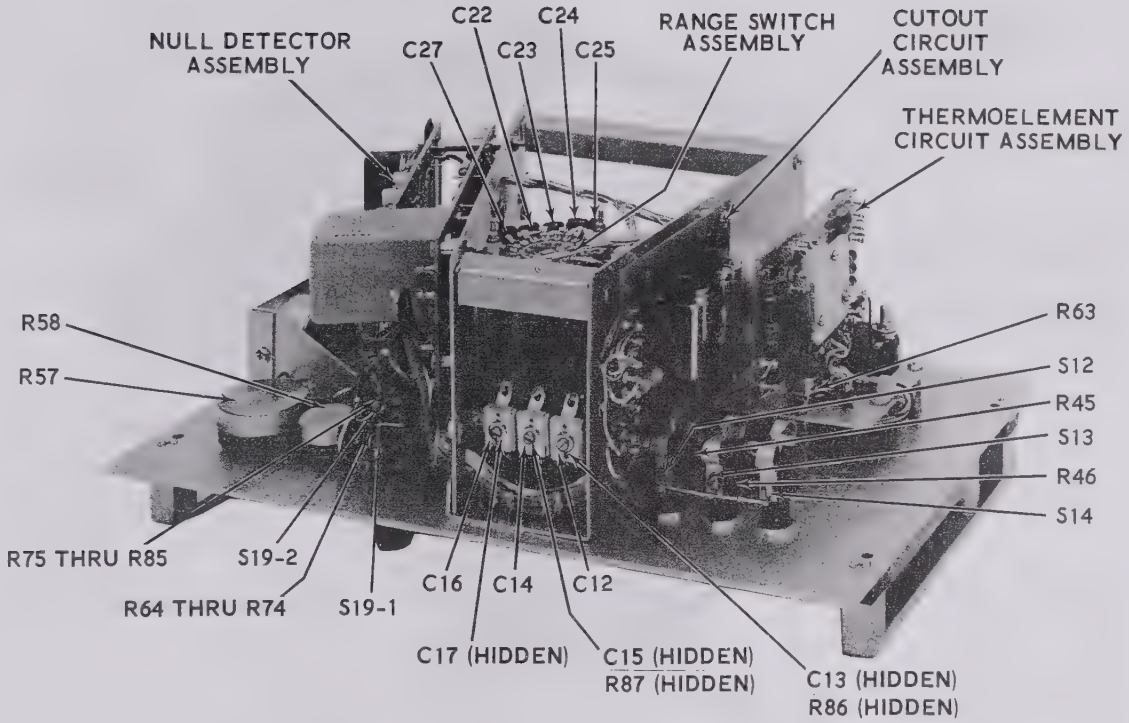


Figure 10. Model 6A Interior - Bottom View

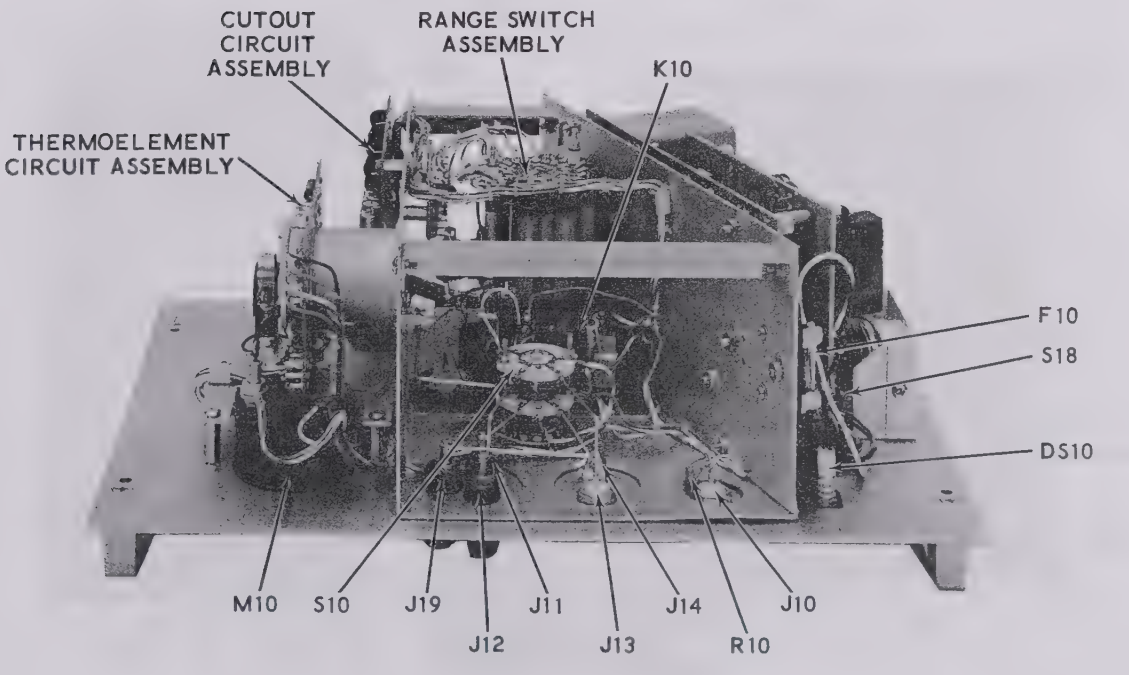


Figure 11. Model 6A Interior - Top View

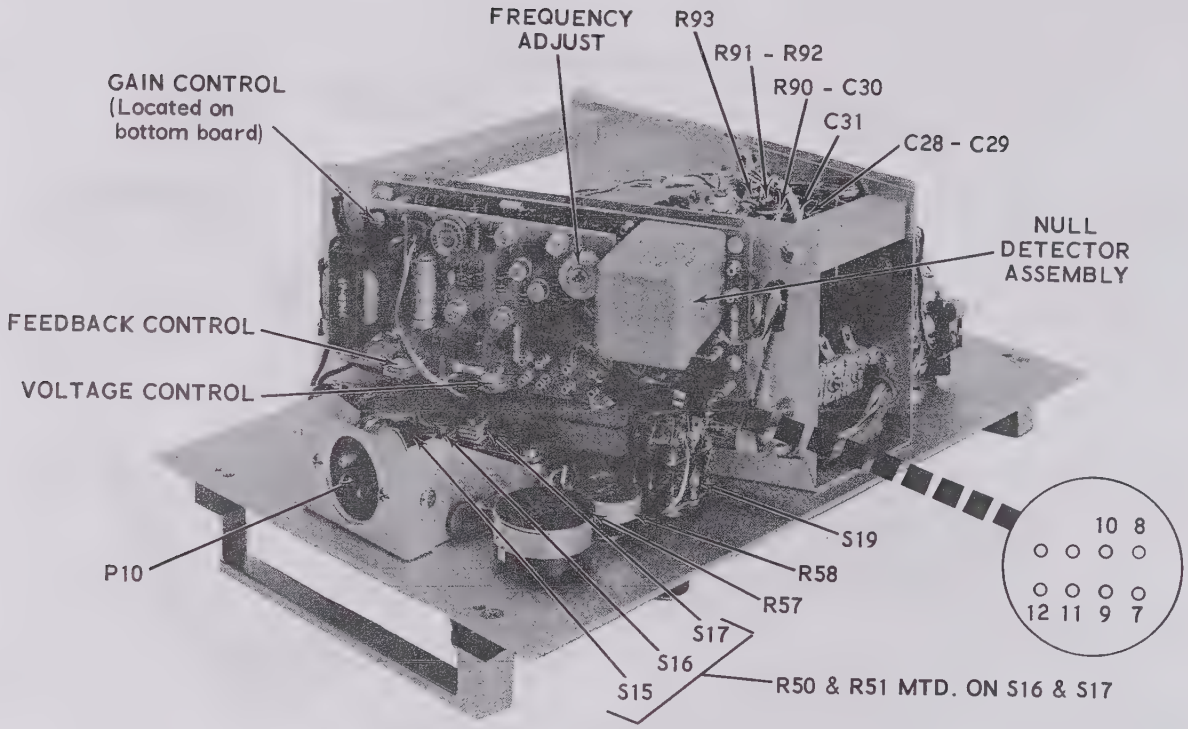


Figure 12. Model 6A Interior - Side View

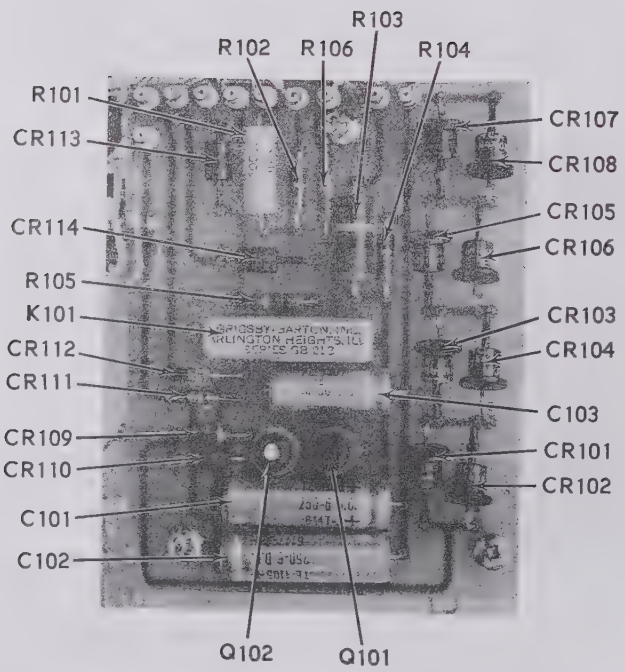


Figure 13. Cutout Circuit Assembly

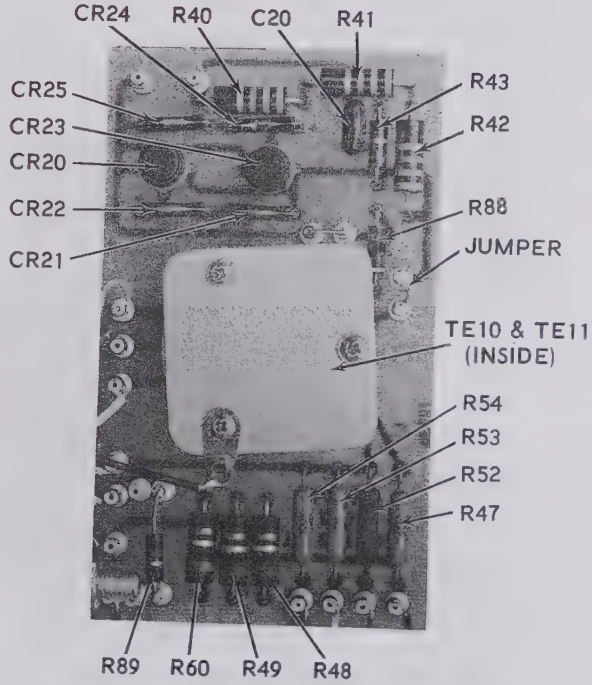


Figure 14. Thermoelement Circuit Assembly

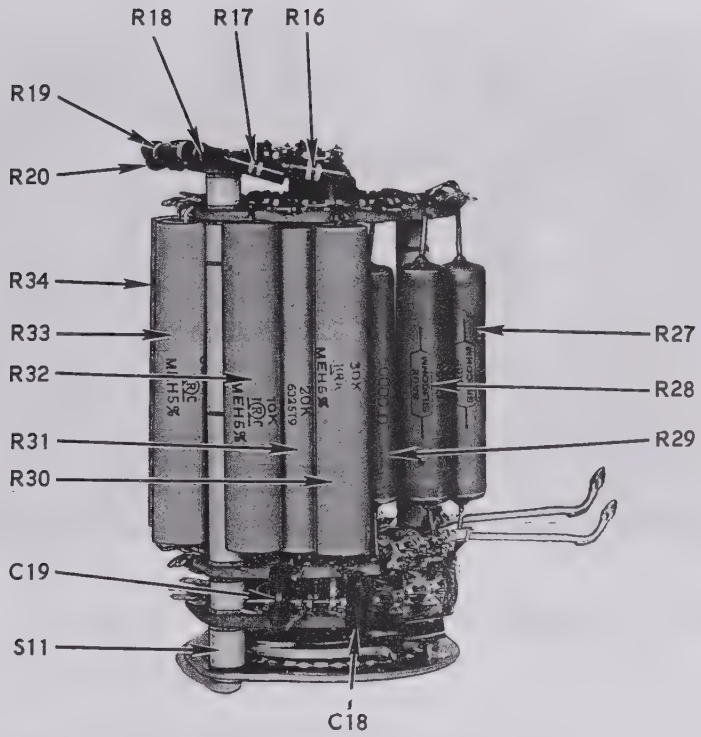


Figure 15. Range Switch Assembly - Front View

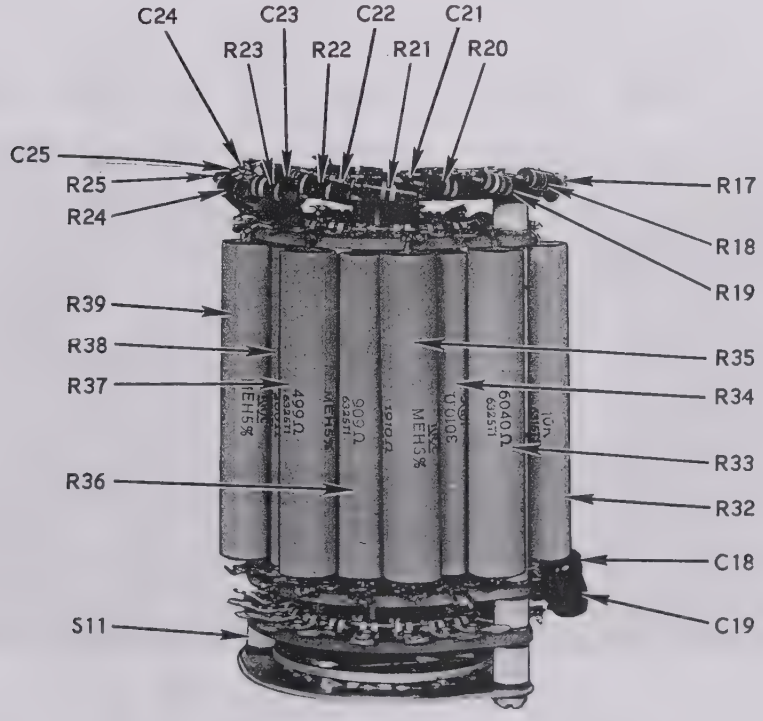


Figure 16. Range Switch Assembly - Rear View

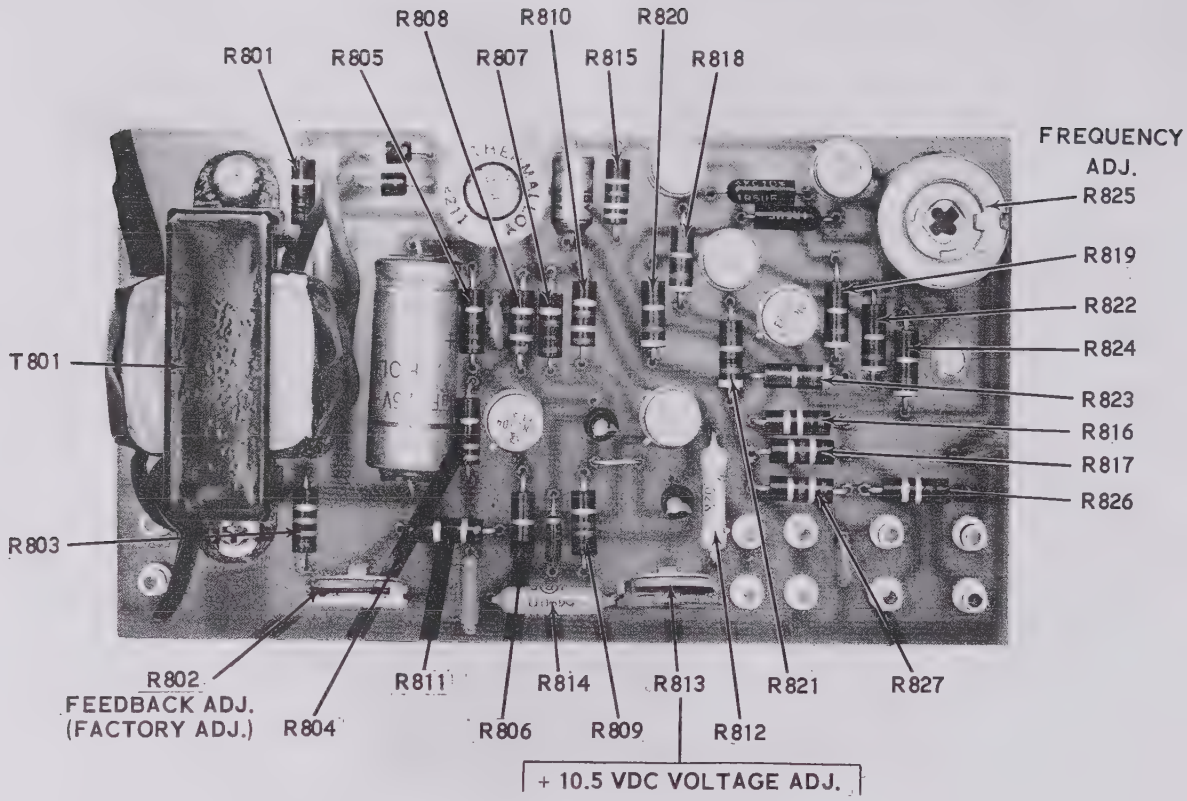


Figure 17. Null Detector Power Supply Board (Detail 1)

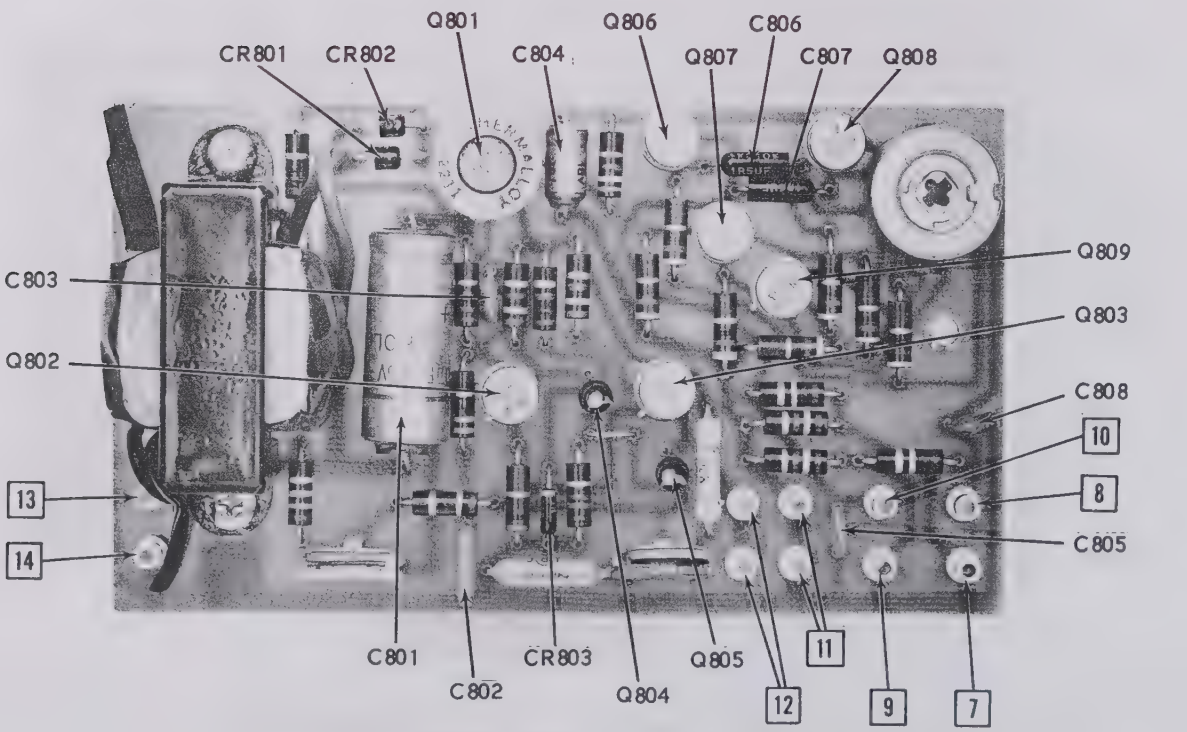


Figure 18. Null Detector Power Supply Board (Detail 2)

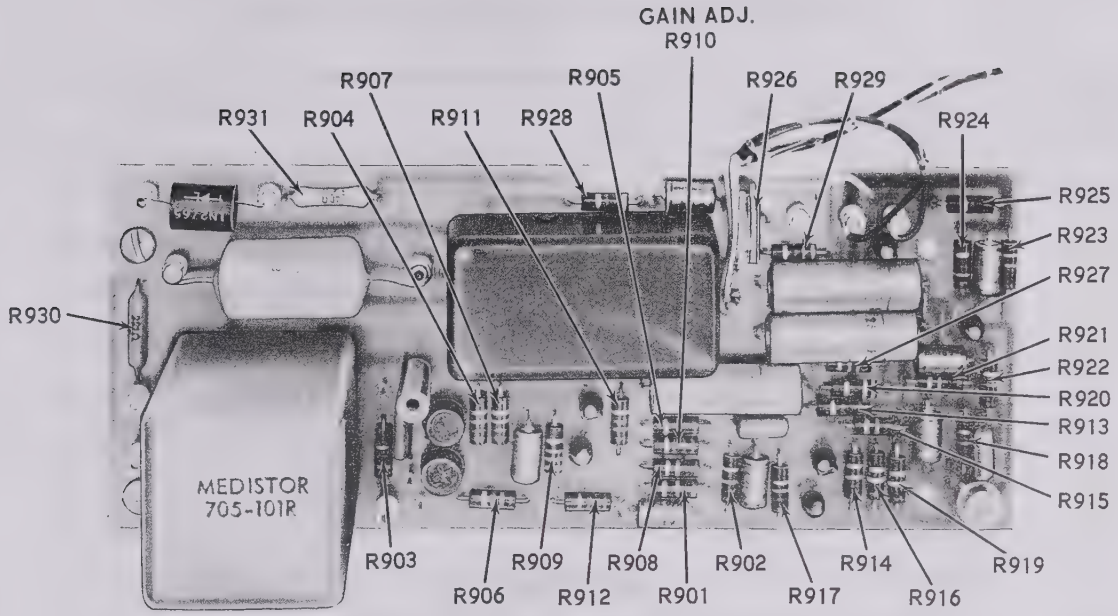


Figure 19. Null Detector Amplifier Board (Detail 1)

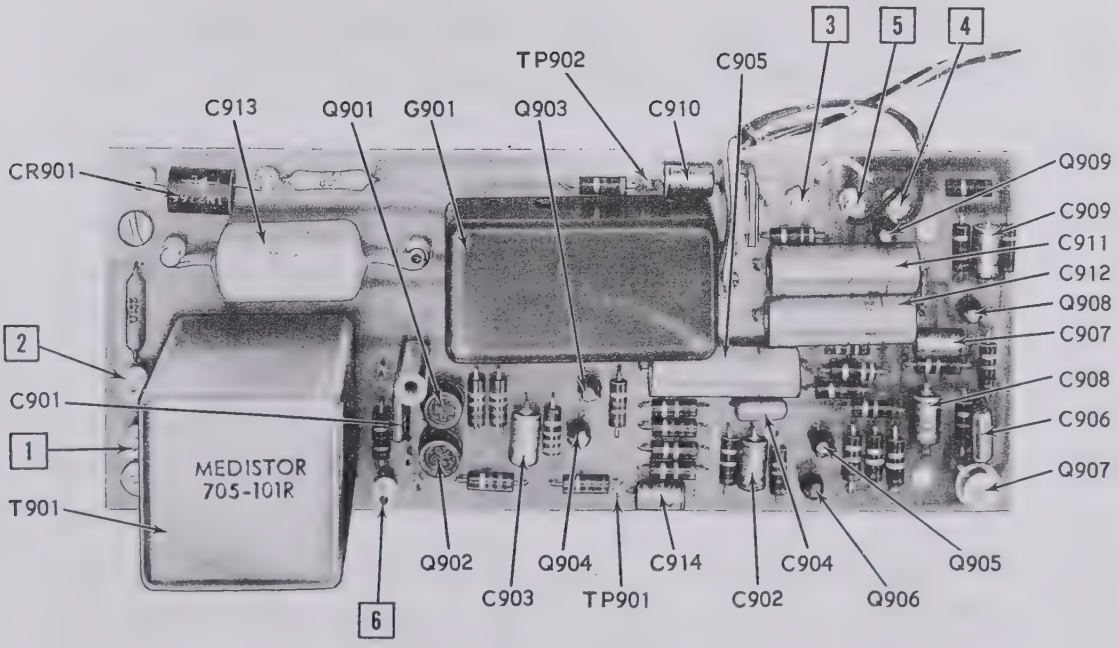


Figure 20. Null Detector Amplifier Board (Detail 2)

SECTION 6
LIST OF REPLACEABLE PARTS

6.1 Parts Description

A complete description and the Holt part number is supplied for each replaceable part. When ordering parts, give the complete description, the Holt part number, the reference number, and the model and serial number of the equipment for which the part is intended. The serial number is located on the back of the panel above the sensitivity buttons on the left end of the case, and in the case of rack mounting, on the back of the left edge of the front panel.

6.2 Parts Illustration

The location of each part in the illustrations in the manual is simplified by the use of the right hand column on the parts pages titled LOCATION - FIGURE NO. The figure number of the illustration in which this part is shown will appear in this column.

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Manufacturer	Catalog Number	Location Figure No.
C12	Capacitor, Variable, 80-480 pf	0908-007	Arco	466	10
C13 *	Capacitor, Mica, 2700 pf, 500 VDC	0907-021	Arco	DM20-272J	10
C14	Capacitor, Variable, 80-480 pf	0908-007	Arco	466	10
C15 *	Capacitor, Mica, 2200 pf, 500 VDC	0907-019	Arco	DM19-222J	10
C16	Capacitor, Variable, 80-480 pf	0908-007	Arco	466	10
C17 *	Capacitor, Mica, 1200 pf, 500 VDC	0907-014	Arco	DM19-122J	10
C18	Capacitor, Mica, 430 pf, 300 VDC	0907-001	Arco	DM15-431J	15,16
C19	Capacitor, Mica, 200 pf, 500 VDC	0907-057	Arco	DM15-201J	15,16
C20	Capacitor, Fixed, 620 pf, 300 VDC	0907-074	Arco	DM15-621J	14
C22	Capacitor, Mica, 50 pf, 500 VDC	0907-041	Arco	DM15-500	10,16
C23	Capacitor, Mica, 50 pf, 500 VDC	0907-041	Arco	DM15-500	10,16
C24	Capacitor, Mica, 150 pf, 500 VDC	0907-054	Arco	DM15-151J	10,16
C25	Capacitor, Ceramic, 150 pf, 1000 VDC	0906-054	Arco	DM15-151J	10,16
C27 *	Capacitor, Mica, 20 pf, 500 VDC	0907-029	Arco	DM15-200J	10
C28	Capacitor, Ceramic, Disc., 400 pf, 3000 V	0906-052	Centralab	DD30-401	12
C29	Capacitor, Ceramic, Disc, 2000 pf, 3000 V	0906-054	Centralab	DD30-202	12
C30	Capacitor, Ceramic, Disc, 1000 pf, 3000 V	0906-053	Centralab	DD30-102	12
C31	Capacitor, Ceramic, Disc, 400 pf, 3000 V	0906-052	Centralab	DD30-401	12
C101	Capacitor, Electrolytic, 250 mfd, 6 V	0905-004	Sprague	TE1105	13
C102	Capacitor, Electrolytic, 250 mfd, 6 V	0905-004	Sprague	TE1105	13
C103	Capacitor, Electrolytic, 50 mfd, 50 V	0905-061	Sprague	TE1307	13
C801	Capacitor, Electrolytic, 250 mfd, 25 V	315-111	Amperex	C437 AR/F250	18
C802	Capacitor, Flat Foil, .022 mfd, 40 V	326-108	Amperex	C280AA/P22K	18
C803	Capacitor, Ceramic Disc, .001 mfd, 1 KV	326-101	Sprague	10292	18
C804	Capacitor, Electrolytic, 20 mfd, 16 V	315-104	Amperex	C426 AR/E20	18
C805	Capacitor, Ceramic Disc, .001 mfd, 1 KV	326-101	Sprague	10292	18
C806	Capacitor, Tantalum, 1.5 mfd, 20 V	311-109	Kemet	KIR5C20K	18
C807	Capacitor, Tantalum, 1.5 mfd, 20 V	311-109	Kemet	KIR5C20K	18
C808	Capacitor, Ceramic Disc, .001 mfd, 1 KV	326-101	Sprague	10292	18

* FACTORY SELECTED VALUE

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Manufacturer	Catalog Number	Location Figure No.
C901	Capacitor, Flat Foil, .022 mfd, 40 V	326-108	Amperex	C280 AA/P22K	20
C902	Capacitor, Electrolytic, 20 mfd, 16 V	315-104	Amperex	C426 AR/E20	20
C903	Capacitor, Electrolytic, 20 mfd, 16 V	315-104	Amperex	C426 AR/E20	20
C904	Capacitor, Flat Foil, .1 mfd, 40 V	326-107	Amperex	C280 AA/P100K	20
C905	Capacitor, Electrolytic, 250 mfd, 16 V	315-109	Amperex	C437 AR/E250	20
C906	Capacitor, Flat Foil, .1 mfd, 40 V	326-107	Amperex	C280 AA/P100K	20
C907	Capacitor, Electrolytic, 20 mfd, 16 V	315-104	Amperex	C426 AR/E20	20
C908	Capacitor, Tantalum, 20 mfd, 20 V	311-106	Kemet	K10C20K	20
C909	Capacitor, Electrolytic, 20 mfd, 16 V	315-104	Amperex	C426 AR/E20	20
C910	Capacitor, Electrolytic, 20 mfd, 16 V	315-104	Amperex	C426 AR/E20	20
C911 & C912	Capacitor, Electrolytic, 250 mfd, 16 V	315-109	Amperex	C437 AR/E250	20
C913	Capacitor, Metallized Mylar, 2 mfd, 250 V	325-025	IEC	CM20000-2	20
C914	Capacitor, Electrolytic, 20 mfd, 16 VDC	315-104	Amperex	C426 AR/E320	20
CR20 *	SCR,	(84293)	GE	2N2322	14
CR21 *	Diode, Silicon, 125 PIV, .004 Amp	(Matched	Texas Inst.	1N628	14
CR22 *	Diode, Silicon, 125 PIV, .004 Amp	Set)	Texas Inst.	1N628	14
CR23 *	SCR,	(84293)	GE	2N2322	14
CR24 *	Diode, Silicon, 125 PIV, .004 Amp	(Matched	Texas Inst.	1N628	14
CR25 *	Diode, Silicon, 125 PIV, .004 Amp	Set)	Texas Inst.	1N628	14
CR101 thru CR108	Diode, Silicon, 100 PIV, .75 Amp	0301-016	RCA	1N440B	13
CR109	Diode, Silicon, 400 PIV	0301-031	Solitron	NS2004	13
CR110	Diode, Silicon, 400 PIV	0301-031	Solitron	NS2004	13
CR111 & CR112	Diode, Germanium, 100 PIV	0302-005	Amperex	1N618	13
CR113	Diode, Silicon, 400 PIV	0301-020	GE	1N3640	13
CR114	Diode, Silicon, 400 PIV	0301-020	GE	1N3640	13
CR801	Diode, Silicon, Rectifier, 4D4	416-272	IRC	4D4	18
CR802	Diode, Silicon, Rectifier, 4D4	416-272	IRC	4D4	18
CR803	Diode, Zener, 6.2 V, 1N753A	421-105	IRC	1N753A	18
CR901	Diode, Reference, Silicon, 1N2765	421-107	TRW	1N2765	12
DS10	Pilot Light Assembly	0502-002	Drake	105	2,11
F10	Fuse, 1/8 Amp, Fast-Blo	1001-010	Little Fuse	3AG	11

* FACTORY SELECTED VALUE

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Manufacturer	Catalog Number	Location Figure No.
F10	Fuse, 1/8 Amp, Fast-Blo	1001-010	Little Fuse	3AG	11
G901	Chopper, DPDT	1204-010	James	C-4287	20
J10	Receptacle, UHF, Female	1704-005	Gremar	6804	2,11
J11	Binding Post, Black	1803-017	Superior	DF30BC	2,11
J12	Binding Post, Red	1803-018	Superior	DF30RC	2,11
J13	Receptacle, UHF, Female	1704-005	Gremar	6804	2,11
J14	Binding Post, Ground	1803-029	Enoch	Special	2,11
J18	Receptacle, 3 pin, Female	1701-006	Amphenol	91PC3F	2
J19	Binding Post, Black	1803-017	Superior	DF30BC	2,11
K10	Relay Assembly	82761	Holt	82761	2,11
K101	Relay, Form C	1203-030	Grigsby-Barton	GB-31C	13
LC10	Line Cord	8502-003	Belden	17460-S	
M10	Meter	1301-009	Triplett	320R-Special	2,11
P10	Male Power Cord Connector	1701-060	Amphenol	160-5	12
P18	Connector, Cover Assembly	82759	Holt	82759	2
Q101	Transistor, NPN, Silicon	0203-008	Fairchild	2N3643	13
Q102	Transistor, PNP, Silicon	0204-004	Fairchild	2N3638	13
Q801	Transistor, Silicon, NPN	440-001	RCA	2N3053	18
Q802 & Q803	Transistor, Germanium, NPN	432-006	Texas Inst.	2N1306	18
Q804 & Q805	Transistor, Silicon, NPN	440-009	GE	2N5133	18
Q806	Transistor, Germanium, PNP	432-007	RCA	2N1307	18
Q807	Transistor, Germanium, NPN	432-006	Texas Inst.	2N1306	18
Q808	Transistor, Germanium, PNP	432-007	RCA	2N1307	18
Q809	Transistor, Germanium, NPN	432-006	Texas Inst.	2N1306	18
Q901	Transistor, Germanium, PNP	432-009	GE	2N508A	20
Q902	Transistor, Germanium, PNP	432-009	GE	2N508A	20
Q903 thru Q906	Transistor, Silicon, NPN	440-009	Fairchild	2N5133	20
Q907	Transistor, Germanium, PNP	432-007	RCA	2N1307	20

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Manufacturer	Catalog Number	Location Figure No.
Q908 & Q909	Transistor, Silicon, NPN	440-009	Fairchild	2N5133	20
R10	Resistor, Metal Film, 499 Ohms, 1/2 Watt, ± 1%	0804-051	IRC	MEC-TO	11
R16	Resistor, Composition, 120 K Ohms, 1/2 Watt, ± 10%	0801-068	Allen Bradley	EB1241	15
R17	Resistor, Composition, 120 K Ohms, 1/2 Watt, ± 10%	0801-068	Allen Bradley	EB1241	15,16
R18	Resistor, Composition, 47 K Ohms, 1/2 Watt, ± 10%	0801-063	Allen Bradley	EB4731	15,16
R19	Resistor, Composition, 39 K Ohms, 1/2 Watt, ± 10%	0801-062	Allen Bradley	EB3931	15,16
R20	Resistor, Composition, 12 K Ohms, 1/2 Watt, ± 10%	0801-057	Allen Bradley	EB1231	15,16
R21	Resistor, Composition, 12 K Ohms, 1/2 Watt, ± 10%	0801-057	Allen Bradley	EB1231	16
R22	Resistor, Composition, 4700 Ohms, 1/2 Watt, ± 10%	0801-052	Allen Bradley	EB4721	16
R23	Resistor, Composition, 3900 Ohms, 1/2 Watt, ± 10%	0801-051	Allen Bradley	EB3931	16
R24	Resistor, Composition, 1200 Ohms, 1/2 Watt, ± 10%	0801-045	Allen Bradley	EB1221	16
R25	Resistor, Composition, 1200 Ohms, 1/2 Watt, ± 10%	0801-045	Allen Bradley	EB1221	16
R27	Resistor, Wire Wound, 200 K Ohms, 10 Watts, ± 5%	0805-069	Sage	1700S	15
R28	Resistor, Wire Wound, 100 K Ohms, 10 Watts, ± 5%	0805-068	Sage	1700S	15
R29	Resistor, Wire Wound, 60 K Ohms, 10 Watts, ± 5%	0805-067	Sage	1700S	15
R30	Resistor, Metal Film, 30 K Ohms, 2 Watts, ± 5%	0804-061	IRC	MEH-T9	15
R31	Resistor, Metal Film, 20 K Ohms, 2 Watts, ± 5%	0804-060	IRC	MEH-T9	15
R32	Resistor, Metal Film, 10 K Ohms, 2 Watts, ± 5%	0804-059	IRC	MEH-T2	15,16
R33	Resistor, Metal Film, 6040 Ohms, 2 Watts, ± 5%	0804-058	IRC	MEH-T1	15,16
R34	Resistor, Metal Film, 3010 Ohms, 2 Watts, ± 5%	0804-057	IRC	MEH-T1	15,16

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Manufacturer	Catalog Number	Location Figure No.
R35	Resistor, Metal Film, 1910 Ohms, 2 Watts, ± 5%	0804-056	IRC	MEH-T1	16
R36	Resistor, Metal Film, 909 Ohms, 2 Watts, ± 5%	0804-055	IRC	MEH-T1	16
R37	Resistor, Metal Film, 499 Ohms, 2 Watts, ± 5%	0804-054	IRC	MEH-T1	16
R38	Resistor, Metal Film, 200 Ohms, 2 Watts, ± 5%	0804-053	IRC	MEH-T1	16
R39	Resistor, Metal Film, 100 Ohms, 2 Watts, ± 5%	0804-052	IRC	MEH-T1	16
R40 thru R42	Resistor, Composition, 3.3 Ohms, 1 Watt, ± 10%	0801-194	Allen Bradley	GBT-1	14
R43	Resistor, Composition, 2700 Ohms, 1/2 Watt, ± 10%	0801-049	Allen Bradley	EB2731	14
R45	Resistor, Metal Film, 4750 Ohms, 1/2 Watt, ± 10%	0804-134	IRC	CEC	10
R46	Resistor, Metal Film, 100 K Ohms, 1/2 Watt, ± 1%	0804-170	IRC	CEC	10
R47	Resistor, Metal Film, 909 Ohms, 1/2 Watt, ± 1%	0804-114	IRC	CEC	14
R48	Resistor, Wire Wound, .30 Ohms, 2 Watts, ± 5%	0802-256	IRC	BWH	14
R49	Resistor, Wire Wound, .30 Ohms, 2 Watts, ± 5%	0802-256	IRC	BWH	14
R50	Resistor, Wire Wound, 1 Ohm, 2 Watts, ± 10%	0802-123	IRC	BWH	12
R51	Resistor, Metal Film, 10 Ohms, 1/2 Watt, ± 1%	0804-232	IRC	CEC	12
R52	Resistor, Carbon Film, 10 M Ohms, 1/2 Watt, ± 1%	0803-129	IRC	DCC	14
R53	Resistor, Metal Film, 1 M Ohms, 1/2 Watt, ± 1%	0804-206	IRC	CEC	14
R54	Resistor, Metal Film, 100 K Ohms, 1/2 Watt, ± 1%	0804-170	IRC	CEC	14
R57	Resistor, Variable, Wire Wound, 2 Ohms, 3 Watts, ± 10%	54394	Holt	54394	2,10,12
R58	Resistor, Variable, Wire Wound, 40 Ohms, 2 Watts, ± 10%	54393	Holt	54393	2,10,12
R60	Resistor, Wire Wound, .30 Ohms, 2 Watts, ± 5%	0802-256	IRC	BWH	14

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Manufacturer	Catalog Number	Location Figure No.
R63	Resistor, Variable, Composition, 100 K Ohms, 1/2 Watt	0806-053	CTS	65	2,10
R64 thru R74	Resistor, Composition, 330 Ohms, 1/2 Watt, ± 10%	0801-038	Allen Bradley	EB3311	10
R75 thru R85	Resistor, Composition, 36 Ohms, 1/2 Watt, ± 5%	0801-197	Allen Bradley	EB3605	10
R86	Resistor, Composition, 8200 Ohms, 1/2 Watt, ± 10%	0801-055	Allen Bradley	EB8221	10
R87	Resistor, Composition, 6800 Ohms, 1/2 Watt, ± 10%	0801-054	Allen Bradley	EB6821	10
R88	Resistor, Composition, 91 Ohms, 1/2 Watt, ± 5%	0801-001	Allen Bradley	EB9105	14
R89 *	Resistor, Composition, 220 Ohms, 1/2 Watt, ± 10%	0801-036	Allen Bradley	EB9105	14
R90	Resistor, Composition, 270 K Ohms, 1/2 Watt, ± 10%	0801-072	Allen Bradley	EB2741	12
R91	Resistor, Composition, 200 K Ohms, 1/2 Watt, ± 5%	0801-013	Allen Bradley	EB2045	12
R92	Resistor, Composition, 200 K Ohms, 1/2 Watt, ± 5%	0801-013	Allen Bradley	EB2045	12
R93	Resistor, Composition, 180 K Ohms, 1/2 Watt, ± 10%	0801-070	Allen Bradley	EB1841	12
R102	Resistor, Composition, 1200 Ohms, 1/2 Watt, ± 10%	0801-045	Allen Bradley	EB1221	13
R103	Resistor, Composition 12 Ohms, 2 Watts, ± 10%	0801-153	Allen Bradley	HB1201	13
R104	Resistor, Composition, 1200 Ohms, 1/2 Watt, ± 10%	0801-045	Allen Bradley	EB1221	13
R105 *	Resistor, Composition, 680 Ohms, 1/2 Watt, ± 10%	0801-042	Allen Bradley	EB6811	13
R106 *	Resistor, Composition, 680 Ohms, 1/2 Watt, ± 10%	0801-042	Allen Bradley	EB6811	13
R801	Resistor, Fixed, Composition, 15 Ohms, 1/2 Watt, 10%	153-150	Stackpole	RC20	17
R802	Potentiometer, Carbon, Tab Mount, 50 K	215-206	CTS	1714, Type X201	17
R803	Resistor, Fixed Composition, 18 K, 1/2 Watt, 10%	153-183	Stackpole	RC20	17

* FACTORY SELECTED VALUE

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Manufacturer	Catalog Number	Location Figure No.
R804	Resistor, Fixed, Composition, 33 Ohms, 1/2 Watt, 10%	153-330	Stackpole	RC20	17
R805	Resistor, Fixed, Composition, 2200 Ohms, 1/2 Watt, 10%	153-222	Stackpole	RC20	17
R806	Resistor, Fixed, Composition, 1000 Ohms, 1/2 Watt, 10%	153-102	Stackpole	RC20	17
R807	Resistor, Fixed, Composition, 1500 Ohms, 1/2 Watt, 10%	153-152	Stackpole	RC20	17
R808	Resistor, Fixed, Composition, 6800 Ohms, 1/2 Watt, 10%	153-682	Stackpole	RC20	17
R809	Resistor, Fixed, Composition, 5600 Ohms, 1/2 Watt, 10%	153-562	Stackpole	RC20	17
R810	Resistor, Fixed, Composition, 6800 Ohms, 1/2 Watt, 10%	153-682	Stackpole	RC20	17
R811	Resistor, Fixed, Composition, 2.7 Megohms, 1/2 Watt, 10%	153-275	Stackpole	RC20	17
R812	Resistor, Fixed, Metal Film, 4020 Ohms, 1/2 Watt, 1%	157-022	IRC	CEC-TO	17
R813	Potentiometer, Carbon, Tab Mount, 2500 Ohms	215-205	CTS	1712, Type X201	17
R814	Resistor, Fixed, Metal Film, 6490 Ohms, 1/2 Watt, 1%	157-017	IRC	CEC-TO	17
R815 *	Resistor, Fixed, Composition, 68 Ohms, 1/2 Watt, 10%	153-680	Stackpole	RC20	17
R816 *	Resistor, Fixed, Composition, 150 K, 1/2 Watt, 10%	153-154	Stackpole	RC20	17
R817	Resistor, Fixed, Composition, 2700 Ohms, 1/2 Watt, 10%	153-272	Stackpole	RC20	17
R818 * thru R820	Resistor, Fixed, Composition, 4700 Ohms, 1/2 Watt, 10%	153-472	Stackpole	RC20	17
R821	Resistor, Fixed, Composition, 47 Ohms, 1/2 Watt, 10%	153-470	Stackpole	RC20	17
R822 thru R824 *	Resistor, Fixed, Composition, 4.7 K, 1/2 Watt, 10%	153-472	Stackpole	RC20	17
R825	Potentiometer, Wire Wound, PC Mount, 500 Ohms	261-501	CTS	BA22895 Type 110	17
R826 *	Resistor, Fixed, Composition, 150 K, 1/2 Watt, 10%	153-154	Stackpole	RC20	17

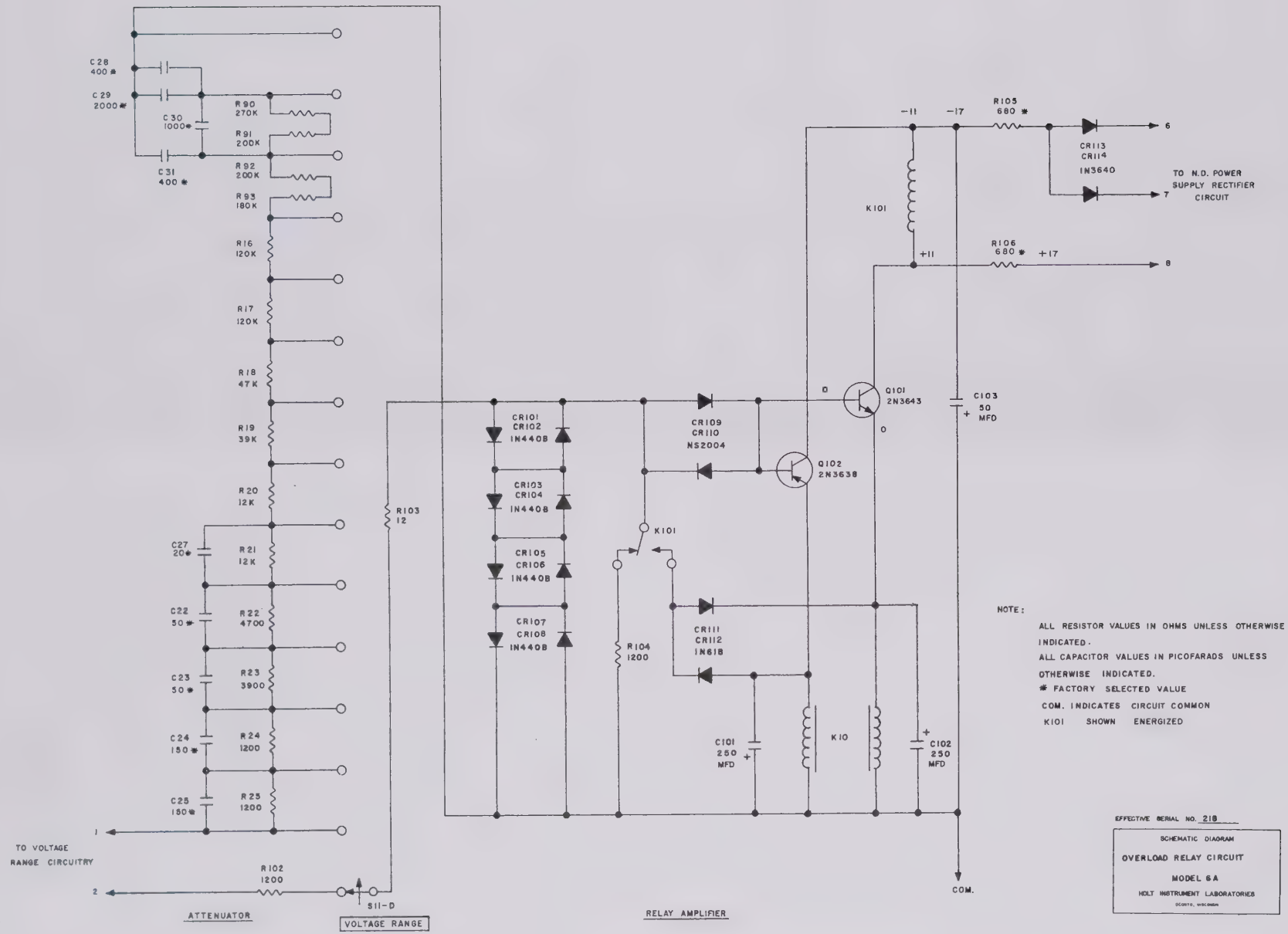
* FACTORY SELECTED VALUE

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Manufacturer	Catalog Number	Location Figure No.
R827	Resistor, Fixed, Composition, 2700 Ohms, 1/2 Watt, 10%	153-272	Stackpole	RC20	17
R901 & R902	Resistor, Fixed, Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	19
R903	Resistor, Fixed, Composition, 18 Megohms, 1/2 Watt, 10%	153-186	Stackpole	RC20	19
R904	Resistor, Fixed, Composition, 22 K, 1/2 Watt, 10%	153-223	Stackpole	RC20	15
R905	Resistor, Fixed, Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	19
R906	Resistor, Fixed, Composition, 560 Ohms, 1/2 Watt, 10%	153-561	Stackpole	RC20	19
R907	Resistor, Fixed, Composition, 22 K, 1/2 Watt, 10%	153-223	Stackpole	RC20	19
R908	Resistor, Fixed, Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	19
R909	Resistor, Fixed, Composition, 33 K, 1/2 Watt, 10%	153-333	Stackpole	RC20	19
R910	Resistor, Fixed, Composition, 1200 Ohms, 1/2 Watt, 10%	153-122	Stackpole	RC20	19
R911	Resistor, Fixed, Composition, 5600 Ohms, 1/2 Watt, 10%	153-562	Stackpole	RC20	19
R912	Resistor, Fixed, Composition, 1500 Ohms, 1/2 Watt, 10%	153-152	Stackpole	RC20	19
R913	Resistor, Fixed, Composition, 1000 Ohms, 1/2 Watt, 10%	153-102	Stackpole	RC20	19
R914	Resistor, Fixed, Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	19
R915	Resistor, Fixed, Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	19
R916	Resistor, Fixed, Composition, 100 K, 1/2 Watt, 10%	153-104	Stackpole	RC20	19
R917	Resistor, Fixed, Composition, 12 K, 1/2 Watt, 10%	153-123	Stackpole	RC20	19
R918	Resistor, Fixed, Composition, 15 K, 1/2 Watt, 10%	153-153	Stackpole	RC20	19
R919	Resistor, Fixed, Composition, 100 K, 1/2 Watt, 10%	153-104	Stackpole	RC20	19
R920 *	Resistor, Composition, 47 Ohms, 1/2 Watt, 10% * FACTORY SELECTED VALUE	153-470	Stackpole	RC20	19

LIST OF REPLACEABLE PARTS

Circuit Symbol	Description	Holt Part No.	Manufacturer	Catalog Number	Location Figure No.
R921 thru R923	Resistor, Fixed, Composition, 10 K, 1/2 Watt, 10%	153-103	Stackpole	RC20	19
R924	Resistor, Fixed, Composition, 6800 Ohms, 1/2 Watt, 10%	153-682	Stackpole	RC20	19
R925	Resistor, Fixed, Composition, 1000 Ohms, 1/2 Watt, 10%	153-102	Stackpole	RC20	19
R926	Potentiometer, Carbon, Tab Mount, 50 K	215-206	CTS	1714, X201	19
R927	Resistor, Composition, 18 K, 1/2 Watt, 10%	153-183	Stackpole	RC20	19
R928	Resistor, Composition, 820 Ohms, 1/2 Watt, 10%	153-821	Stackpole	RC20	19
R929	Resistor, Composition, 1200 Ohms, 1/2 Watt, 10%	153-122	Stackpole	RC20	19
R930	Resistor, Metal Film, 221 Ohms, 1/2 Watt, ± 1%	157-044	Electra	MF7C	19
R931	Resistor, Metal Film, 340 Ohms, 1/2 Watt, ± 1%	157-046	Electra	MF7C	19
S10	Switch, 2 Pole, 3 Position	1101-017	Oak	Special	2,11
S11	Switch, 4 Pole, 15 Position	1101-016	Oak	Special	2,15,16
S12	Galvo Key, SPST	1102-004	L&N	P1123-L	2,10
S13	Galvo Key, SPST	1102-004	L&N	P1123-L	2,10
S14	Galvo Key, SPST	1102-004	L&N	P1123-L	2,10
S15 thru S17	Switch, Push Button, SPDT	1102-002	SwitchCraft	FF1003	2,12
S18	Switch, SPST	1103-003	AH&H	83001	2,11
S19	Switch, 2 Pole, 12 Position, Dual Conc.	1101-060	CTS	Special	2,10,12
T801	Transformer, Power	705-002	Triad	F94-X	17
T901	Transformer, Input	705-101	Nytronics	705-101	20
TE10	Thermoelement, Dual, 5 MA, .01% Reversal	0401-005			14
TE11	Thermoelement, 5 MA	0401-006			



NOTE:

ALL RESISTOR VALUES IN OHMS UNLESS OTHERWISE INDICATED.

ALL CAPACITOR VALUES IN PICOFARADS UNLESS OTHERWISE INDICATED.

* FACTORY SELECTED VALUE

COM. INDICATES CIRCUIT COMMON

K101 SHOWN ENERGIZED

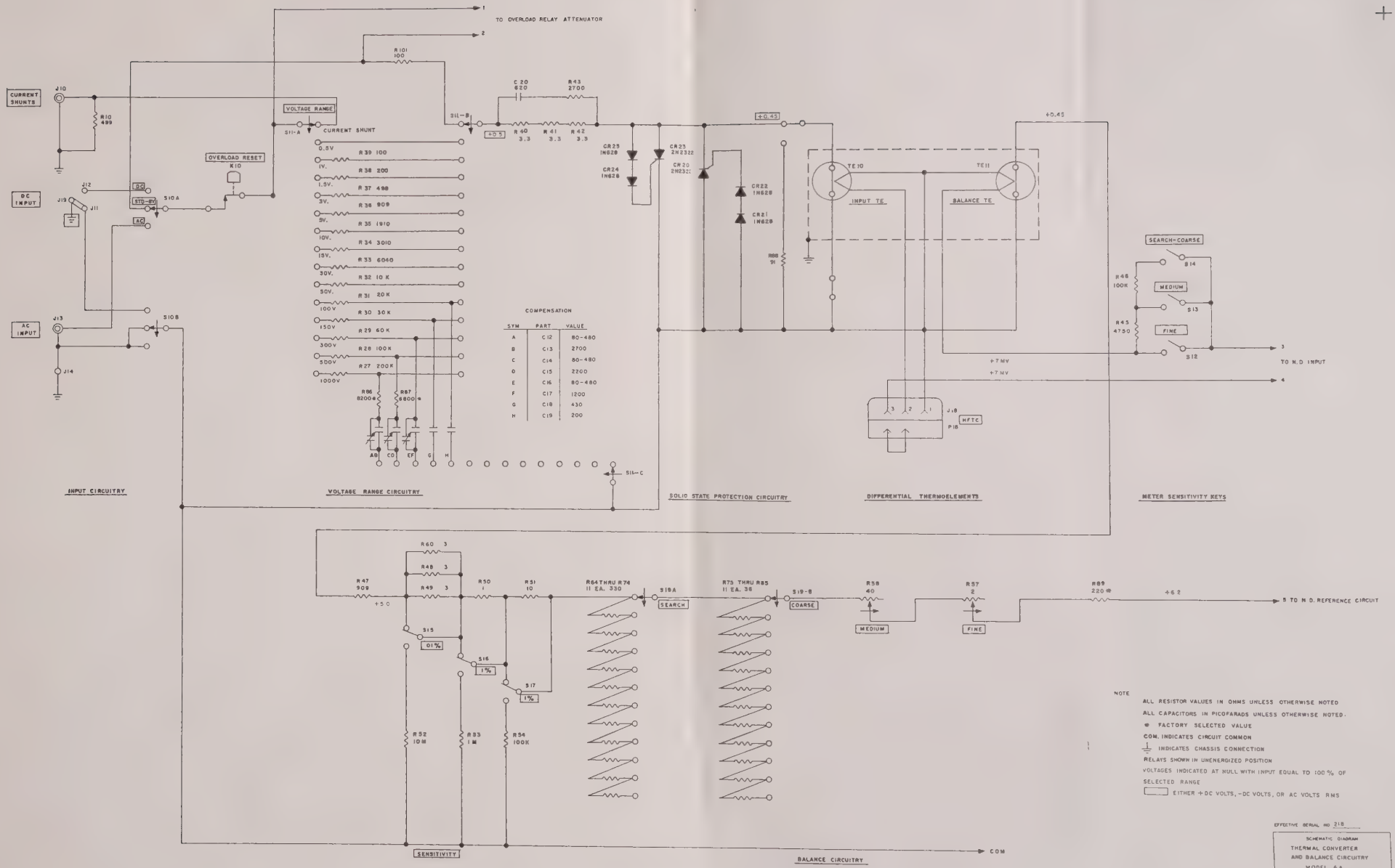
EFFECTIVE SERIAL NO. 218

SCHEMATIC DIAGRAM

OVERLOAD RELAY CIRCUIT

MODEL 6A

HOLT INSTRUMENT LABORATORIES



NOTE

ALL RESISTOR VALUES IN OHMS UNLESS OTHERWISE NOTED

ALL CAPACITORS IN PICOFARADS UNLESS OTHERWISE NOTED.

Ω FACTORY SELECTED VALUE

COM. INDICATES CIRCUIT COMMON

⏚ INDICATES CHASSIS CONNECTION

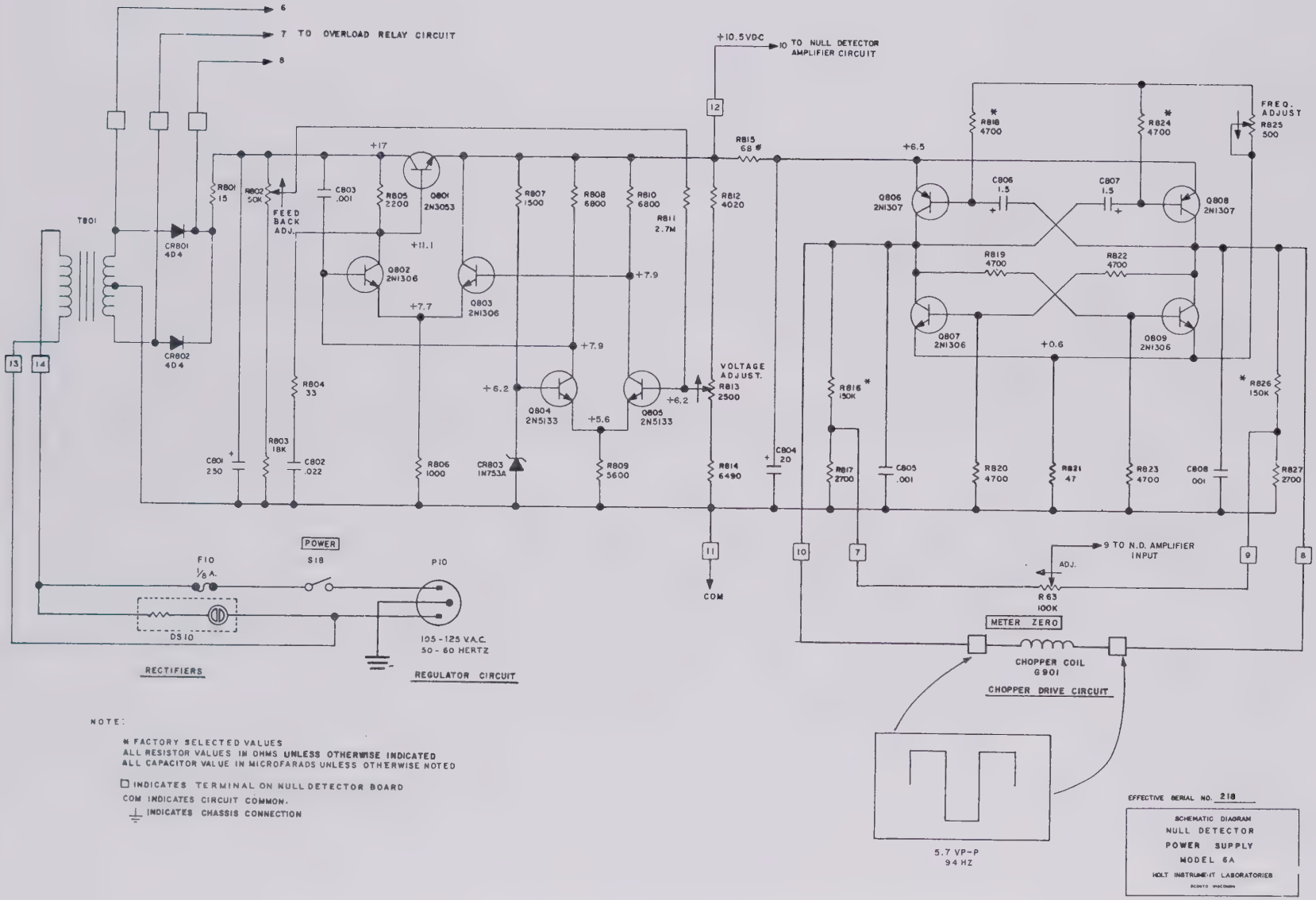
RELAYS SHOWN IN UNENERGIZED POSITION

VOLTAGES INDICATED AT NULL WITH INPUT EQUAL TO 100% OF SELECTED RANGE

▭ EITHER +DC VOLTS, -DC VOLTS, OR AC VOLTS RMS

EFFECTIVE SERIAL NO 218

SCHEMATIC DIAGRAM
THERMAL CONVERTER AND BALANCE CIRCUITRY
MODEL 6A
HOLT INSTRUMENT LABORATORIES



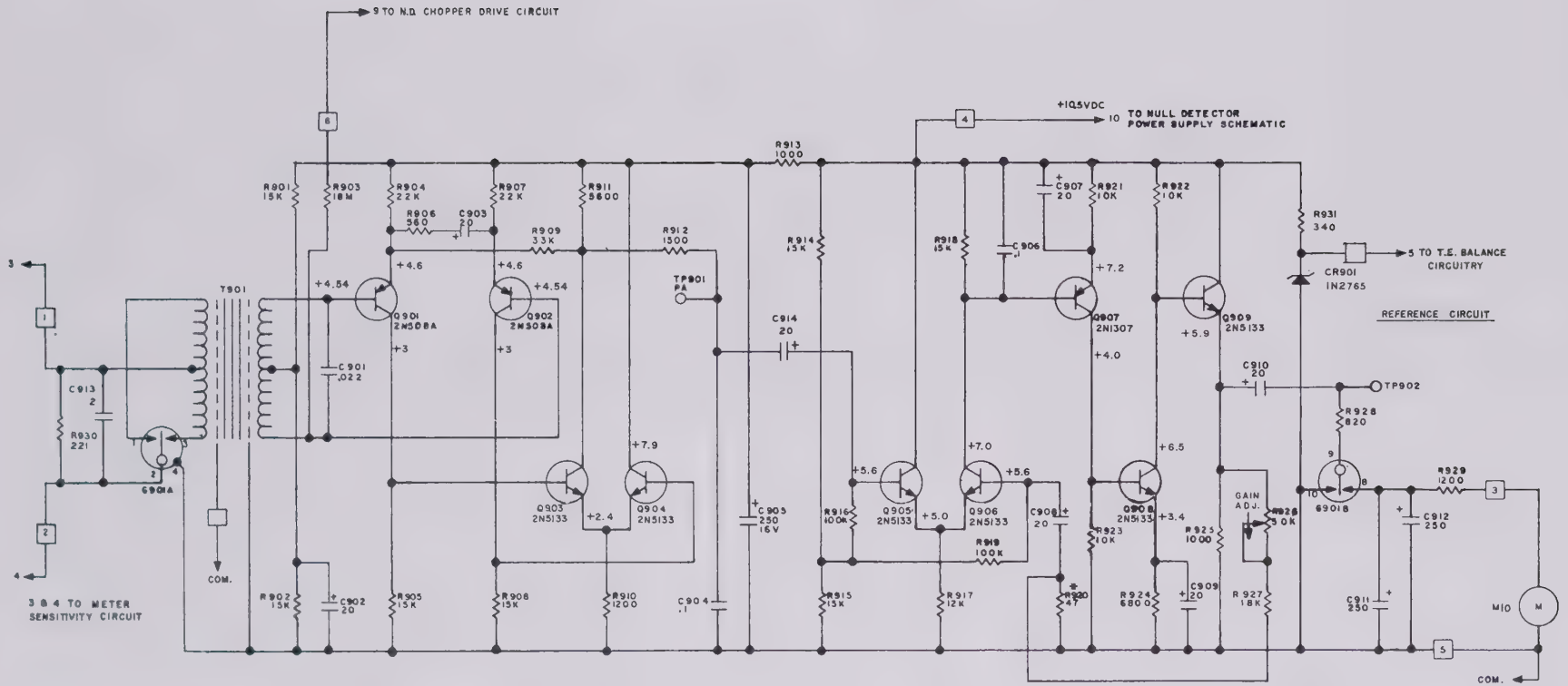
NOTE:

* FACTORY SELECTED VALUES
ALL RESISTOR VALUES IN OHMS UNLESS OTHERWISE INDICATED
ALL CAPACITOR VALUE IN MICROFARADS UNLESS OTHERWISE NOTED

□ INDICATES TERMINAL ON NULL DETECTOR BOARD
COM INDICATES CIRCUIT COMMON.
⏚ INDICATES CHASSIS CONNECTION

EFFECTIVE SERIAL NO. 218

SCHEMATIC DIAGRAM
NULL DETECTOR
POWER SUPPLY
MODEL 6A
HOLT INSTRUMENT LABORATORIES



NOTE:

* FACTORY SELECTED VALUES
ALL RESISTORS VALUES IN OHMS UNLESS OTHERWISE NOTED.
ALL CAPACITOR VALUES MICROFARADS UNLESS OTHERWISE NOTED.
COM. INDICATES CIRCUIT COMMON.
☐ INDICATES TERMINAL ON NULL DETECTOR BOARD.

EFFECTIVE SERIAL NO. 218

SCHEMATIC DIAGRAM

NULL DETECTOR AMPLIFIER

MODEL 6A

HOLT INSTRUMENT LABORATORIES

TROUBLE SHOOTING INFORMATION

1. Follow procedures outlined in manual section 4.

   1.1 Check voltage and frequency, as called for in paragraph 4.2.

   1.2. Check Null Detector gain per paragraph 4.2.

      A. If meter remains to left regardless of adjustments - make thermocouple check per section 2.2B below.

      B. If proper gain cannot be reached with the GAIN control, then R920 should be selected to a different value. If the null detector gain remains too high, this value should be increased.

   1.3. Check percentage voltage range of the 6A as outlined in paragraph 4.3.

      A. In later serial numbered instruments, the variable resistor, R55, was replaced by a fixed resistor, R89. This change lessened the probability of noise or erratic operation. If this check requires an adjustment it will be necessary to change this resistor to one of a different value.

   1.4. The tests for checking the protection circuit are covered in paragraph 4.4C and D. To reduce the contact resistance of the overload relay contacts they may be cleaned with a 600 grit paper or crocus cloth. Then clean the contacts with a liquid cleaner to remove any particles. The stationary and moveable magnetic faces of the overload relay, K10, may be cleaned with a freon type solvent. When dry insert a piece of masking tape or other pressure sensitive tape and close the moveable magnetic face to the body of the stationary pole and while a light pressure is applied withdraw the tape. Do this several times with adhesive side to each pole face, using clean tape each time. This will remove any magnetic materials. Be sure the tape used does not leave any adhesive residue. Do these steps before making any adjustments. Be careful to avoid bending or damaging the moveable spring. Retest trip points and if adjustment is called for, then proceed. The adjustment of the ceramic magnet can be done easier if the two screws holding the laminations are loosened about one or two turns. After adjustment is completed, retighten.

2. Null Detector Assembly

2.1. Power supply and chopper drive circuit are covered in the manual paragraph 3.7B. The DC voltage on units prior to S/N 219 are set for 11.5 volts. Those after S/N 219 are set for 10.5 volts. This adjustment is made by a variable resistor, R813, as shown in Fig. 17. This circuit is straightforward and should present no service problem.

The chopper voltage is generated by a multivibrator circuit, Q806, 7, 8 & 9. The signal at the chopper or terminals 8 & 10 should be 14-17 volts peak to peak and a reasonable square wave at a frequency of 94 Hz $\pm$ 1 Hz. If C806 or C807 or any of the four transistors develop leakage the voltage and waveform will suffer. If the square wave voltage is incorrect it may be adjusted by changing R815. If the waveform is very unsymmetrical the transistors should be suspects.

2.2. Null indicating circuit operation is described in the manual paragraph 3.6. and 3.7A.

A. It is very difficult to obtain indicative signal readings in the first half of the amplifier. A quick check may be obtained by connecting a scope to pin 9 of the chopper and common. With the unit in operate, no voltage input to the input terminals and S12 (FINE sensitivity key) depressed, a square wave should be observed on the scope. Its amplitude should be about 150 MV. Look for breaks in the horizontal portion. Breaks indicate bounce of the chopper contacts. There will be a sharp spike of two to four volts at the leading edge, which is normal. If no signal is observed check the voltage at bucking couple output terminals. Refer to Figure 14. These are found diagonally opposite the ones indicated with a JUMPER. This should read 3 to 7 millivolts depending on the position of the BALANCE controls. If no voltage is obtained at this point check for driving voltage to the heater of TE 11 at the ends of R47 and R52, nearest the heat sink. It should show between .25 to .5 volts depending on the position of BALANCE controls. If no voltage is found here, check back through the source circuit. If voltage is found here but not at the output then the couple is defective or may have the printed circuit shorted where it comes under the oven case. If voltage is found at the output of the couple then check for the same voltage at terminals 1 and 2 as shown in Fig. 20. If voltage is found here but still no indication on the scope connected to the output arm of the chopper, G901, the problem is somewhere in the amplifier. The first suspect would be the chopper, the second transistors and thirdly coupling capacitors.

B. To check the input couple, TE10, set the function switch to DC, voltage switch to 1 volt, apply 1 volt to DC terminals. The output of the couple at the stake on terminals should read .003 to .007 volts. The upper terminal is + in relation to the center terminal of Fig. 14. If no signal is obtained, loosen mounting screws of aluminum oven case to ascertain if the printed circuit may be shorted to the case.

2.3. Chopper

A. The operation of the chopper is explained in paragraph 3.7. of the manual.

B. Determine that the chopper is being driven by a 14-17 volt square wave and that the chopper output as checked per 2.2A above is not correct.

C. Stevens Arnold chopper, #CH1142-94, is used in some units. To remove the cover, four side screws have to be removed. This may necessitate the removal of some components first. With the cover removed, the 6A turned on and chopper running, spray a freon type cleaner at the contacts. Do not try to clean contacts with any abrasives. A readily obtained, aerosol propellant cleaner is CONTACT RE-NU, Miller-Stephenson Chemical Co. #MS230. If the contacts are very dirty their FLUX REMOVER, MS190, applied first and then washed away with the MS230 does well. Due to the cooling effect, the adjustment of the chopper will be altered. Let unit run for five minutes, then slip the cover back on to keep out dust, etc. Let run for thirty minutes for the chopper to stabilize its temperature. Recheck the pattern on the scope, if the waveform is still incorrect, the chopper will require adjustment. This chopper has fixed stationary gold contact wires. Do not attempt to adjust them. The reed is actually two separate reeds, each adjustable. Looking at the coil end, two vertical bars with a Phillips screw at each end will be found. To adjust a reed, loosen one screw minutely and tighten the other, while observing the scope waveform. The left bar adjusts the input (modulating) reed and the right bar the output (demodulating) reed. This procedure will work if the adjustments required are small. If the chopper is badly out of adjustment then see procedure under CHOPPER TEST CIRCUIT below. After each adjustment allow chopper to run with cover in place for 15-30 minutes to see if temperature, strains, etc., cause any changes. After the final adjustment, allow unit to run for at least 24 hours to observe any further changes.

D. James chopper #4287 is also used and is directly replaceable. In a few cases, James incorrectly wired one reed causing a phase reversal. This can be corrected externally by switching the yellow and blue wires to the input section contact terminals. It may also be necessary to reverse leads to terminals 7-9 on power supply board for proper operation of Meter Zero Pot. This chopper has no adjustment on the reed. However, the four fixed contacts are adjustable. The adjusting screws have cross slotted heads and required a REED PRINCE screw driver for making adjustments. A normal PHILLIPS screw driver is likely to spread the head and cause the screw to bind so badly that further adjustment is impossible.

The contacts may be cleaned in the same manner as described in 2.3.c. The lower screws adjust the input and the upper screws the output circuit.

E. Chopper Test Circuit

If a chopper cannot be adjusted in the unit to obtain satisfactory performance, it is necessary to remove the chopper and test it in a circuit as shown in Fig. 1. It is best to remove the solder from each of the ten pins with a wicking braid. Then the chopper can be easily lifted free. Connect as shown in schematic Fig. 1. It is desirable to use a dual trace scope to obtain two waveforms as shown in Fig. 1A, with a short period of crossover. On the JAMES chopper it is easier to back out the two top adjustments a 1/4 turn. Then adjust the lower screws for correct pattern. Then readjust the top screws for proper waveform. If done properly, it will not be necessary to readjust the lower screws. Recheck after cover is replaced. The steel cover can affect the setting slightly. The correct crossover point is the first one obtained as the adjusting screw is turned in. Slightly more crossover time on the upper screws is preferred. This type of adjustment is not always possible with the Stevens Arnold chopper because it has reed adjustment only. The interrupted pattern as shown in Fig. 2B. is not desirable. Adjust to eliminate. After adjustments, let run for several hours in test fixture and recheck.

After this adjustment, reinstall in null detector assembly. While operating with all sensitivity keys up observe movement of meter needle. It should remain within $\pm$ 3/4 of one minor division. Allow to run steady for 24 hours and observe if it is still steady. However, before making adjustments, check frequency and P-P voltage of the drive as called for in 2.1. above. Also check amplifier operation.

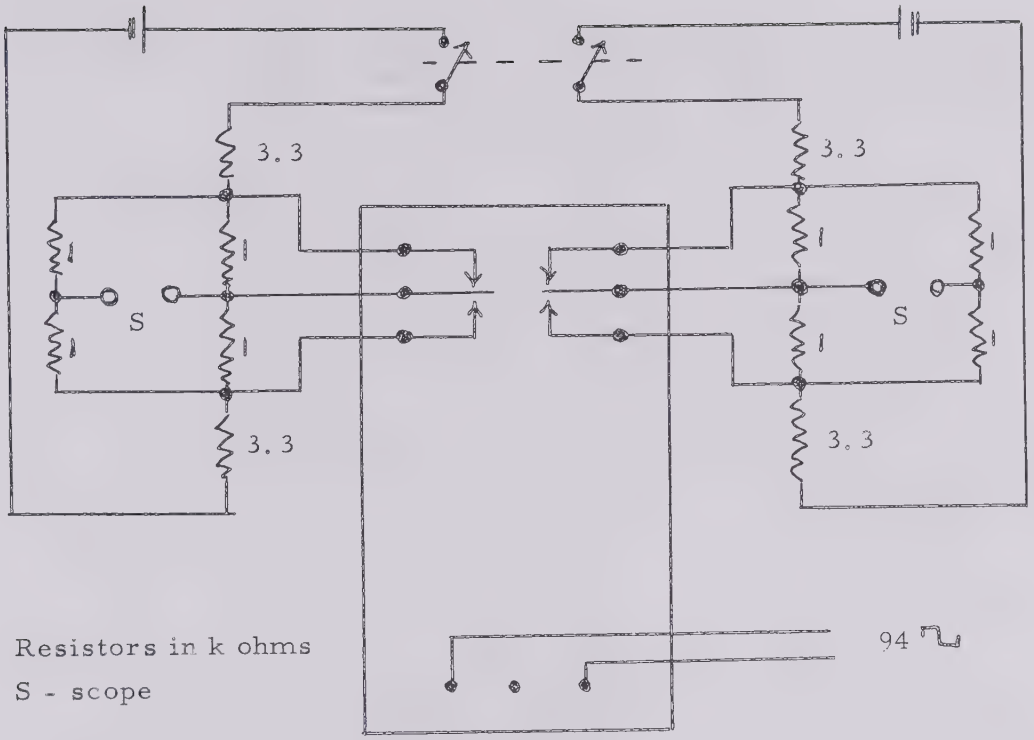


FIGURE 1.

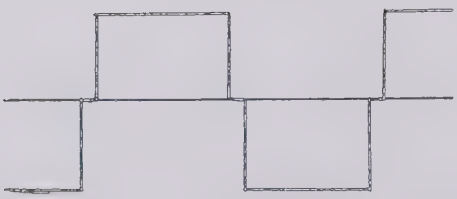


FIGURE 2A.

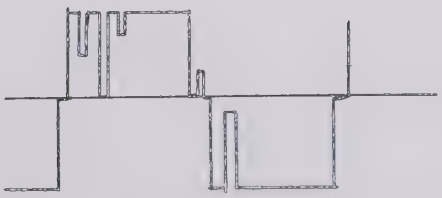


FIGURE 2B.

2.4. Null Amplifier Circuit

A. Description of operation is given in manual paragraph 3.7C.

B. The DC voltages should be checked for values shown on the schematic. The earlier models had a slightly different circuit. Basically it is similar and should present little problem to diagnose.

C. Random instability of meter indication is probably the hardest problem to solve. Test point, 901, may be shunted with a capacitor of 200 mfd or more. The test point is +. This will bypass any noise feeding from the first half of the amplifier. If the needle movement continues with the same amplitude the problem is in the second section of the amplifier. Probably the easiest way to find the source of noise generation is to substitute components. The chopper by this time has been checked. Try substituting in the following order:

1. C914 - 20 mfd Cap.
2. C908 - 20 mfd Cap.
3. C909 - 20 mfd Cap.
4. C910 - 20 mfd Cap.
5. C907 - 20 mfd Cap.
6. C911 - 250 mfd Cap.
7. C912 - 250 mfd Cap.
8. Q905 & Q906 pair
9. Q907, Q908 & Q909

See transistor substitution list.

If the problem is in the first section try substitution as follows:

1. Q901 & Q902 pair
2. Q903 & Q904 pair
3. C902 - 20 mfd
4. C903 - 20 mfd

Only rarely does a fixed resistor present this type of problem. Occasionally one of the variable resistors may develop an erratic contact. Turning to another point will usually make a change in stability. It should be replaced.

D. Transistor types may be substituted as shown below.

Original	Substitutes		
2N508A	2N1193	2N1189	2N1185
2N2926	2N5133	MPS2926	
2N1305	2N1307	2N1309	
2N1304	2N1306	2N1308	
2N3053	2N3498		

Where pairs are indicated, any substitutions of a type should also be done by pairs.

99515